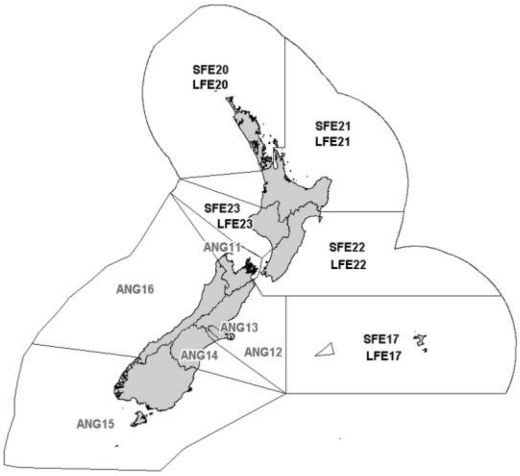
FRESHWATER EELS (SFE, LFE, ANG)

(Anguilla australis, Anguilla dieffenbachii, Anguilla reinhardtii)



1. FISHERY SUMMARY

1.1 Commercial fisheries

The freshwater eel fishery is distributed throughout accessible freshwaters (lakes, rivers, streams, farm ponds, tarns) and some estuarine and coastal waters of New Zealand, including the Chatham Islands. The contemporary commercial fishery dates from the mid-1960s when markets were established in Europe and Asia.

The New Zealand eel fishery is based on the two temperate species of freshwater eels occurring in New Zealand, the shortfin eel *Anguilla australis* and the longfin eel *A. dieffenbachii*. A third species of freshwater eel, the Australasian longfin (*A. reinhardtii*), identified in 1996, has been confirmed from North Island landings. The proportion of this species in landings is unknown but is thought to be small. Virtually all eels (98%) are caught with fyke nets. Eel catches are greatly influenced by water temperature, flood events (increased catches) and drought conditions (reduced catches). Catches decline in winter months (May to September), particularly in the South Island where fishing ceases.

The South Island eel fishery was introduced into the Quota Management System (QMS) on 1 October 2000 with shortfin and longfin species combined into six fish stocks (codes ANG 11 to ANG 16). The Chatham Island fishery was introduced into the QMS on 1 October 2003 with two fish stocks (shortfins and longfins separated into SFE 17 and LFE 17, respectively). The North Island eel fishery was introduced into the QMS on 1 October 2004 with eight fish stocks (four longfin stocks LFE 20–23 and four shortfin stocks SFE 20–23). The Australasian longfin eel is combined as part of the shortfin eel stocks in the Chatham and North Islands, as this species has productivity characteristics closer to shortfins than longfins, and because the catch is not sufficient to justify its own separate stocks. The occasional catch of Australasian longfins is mainly confined to the upper North Island.

The fishing year for all stocks extends from 1 October to 30 September except for ANG 13 (Te Waihora/Lake Ellesmere) which has a fishing year from 1 February to 31 January (since 2002). Currently, there exist minimum and maximum commercial size limits for both longfins and shortfins (220 g and 4 kg, respectively) throughout New Zealand. North Island quota owners agreed in August 2012 to use 31mm escapement tubes (equivalent to South Island regulation). The minimum legal diameter for escape tubes on the North Island was increased to 31mm in October 2013. Quota owners from both islands formally agreed in 1995–96 not to land migratory female longfin eels. In the South Island the eel industry agreed to voluntary incremental increases in the diameter of escape tubes in fyke nets which increased from 25 mm to 26 mm in 1990–91, to 27 mm in 1993–94, to 28.5 mm in 1994–95, and finally to 31 mm in 1997–98, which effectively increases the minimum size limit of both main species to about 300 g. Since about 2006 there has been a voluntary code of practise to return all longfin eels caught in Te Waihora; catches of these longfins are recorded on Eel Catch Effort Returns (ECERs), but not on the Eel Catch Landing Returns (ECLRs).

In early 2005 the Mohaka, Motu and much of the Whanganui River catchments were closed to commercial fishing and there are a number of smaller areas elsewhere that have been reserved as customary fisheries (see Section 1.3). In addition, all Public Conservation lands managed by the Department of Conservation require at a minimum a concession to be commercially fished and in most cases are closed to commercial fishing. In the Waikato-Tainui rohe (region), fisheries bylaws were introduced in March 2014 to limit the minimum harvest size to 300 g for SFE and 400 g for LFE. Amongst other things, these bylaws also introduced an upper limit of 2 kg for both species (to prevent the taking of longfin females that are in a migratory state) and added seasonal closures in some reaches.

Commercial catch data are available from 1965 and originate from different sources. Catch data prior to 1988 are for calendar years, whereas those from 1988 onwards are for fishing years (Table 1, Figure 1). Licensed Fish Receiver Returns (LFRRs), Quota Management Reports (QMRs), and Monthly Harvest Returns (MHRs) provide the most accurate data on landings over the period 1988–89 to 2011–12 for the whole of New Zealand.

Table 1: Eel catch data (t) from for calendar years 1965 to 1988 and fishing years 1988–89 to 2014–15 based on MAF Fisheries Statistics Unit (FSU) and Licensed Fish Receiver Returns (LFRR), Quota Management Reports (QMR), and Monthly Harvest Returns (MHR).

Year	Landings	Year	Landings	Year	Landings	Year	Landings
1965	30	1978	1 583	1988–89	1 315	2001–02	978
1966	50	1979	1 640	1989–90	1 356	2002–03	808
1967	140	1980	1 395	1990–91	1 590	2003–04	729
1968	320	1981	1 043	1991–92	1 585	2004–05	708
1969	450	1982	872	1992–93	1 466	2005–06	771
1970	880	1983	1 206	1993–94	1 255	2006–07	718
1971	1 450	1984	1 401	1994–95	1 438	2007–08	660
1972	2 077	1985	1 505	1995–96	1 429	2008–09	518
1973	1 310	1986	1 166	1996–97	1 342	2009–10	560
1974	860	1987	1 114	1997–98	1 210	2010–11	626
1975	1 185	1988	1 281	1998–99	1 219	2011–12	755
1976	1 501			1999–00	1 133	2012–13	717
1977	906			2000–01	1 071	2013–14	678
						2014–15	547

MAF data, 1965–1982; FSU, 1983 to 1989–90; CELR, 1990–91 to 1999–00; ECLR 2000–01 to 2003–04; MHR 2004–05–present.

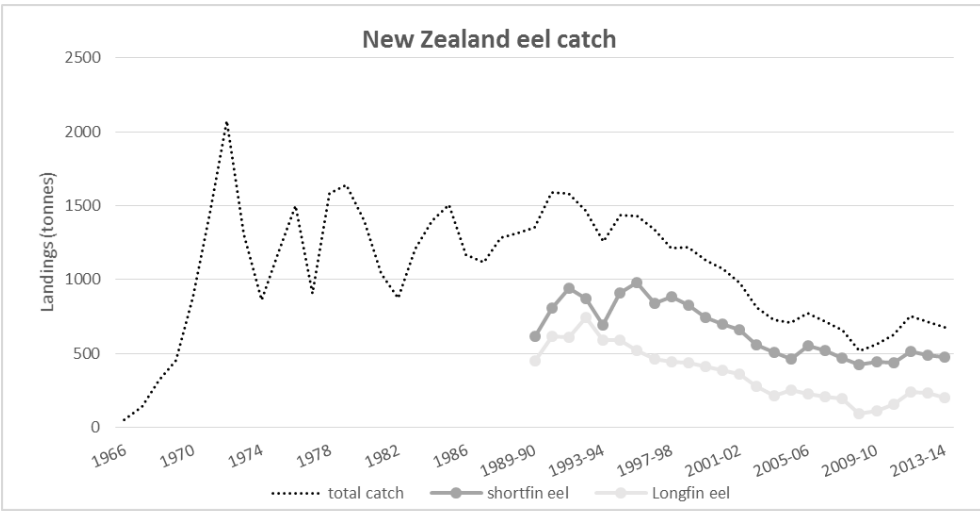


Figure 1: Total eel landings from 1965 to 2014–15, as well as separate shortfin and longfin landings from 1989–90 to 2014–15. The diamond points represent estimates for the period prior to the introduction of Eel Catch Landing Return (ECLR) forms, and were generated by pro-rating the unidentified eel catch by the LFE:SFE ratio (see below). Squares represent post QMS data based on Monthly Harvest Returns (MHR).

There was a rapid increase in commercial catches during the late 1960s, with catches rising to a peak of 2077 t in 1972. Landings were relatively stable from 1983 to 2000, a period when access to the fishery was restricted, although overall catch limits were not in place. In 2000–01 landings dropped to 1070 t, and these were further reduced during 2001–02 to 2004–05 as eel stocks were progressively introduced into the Quota Management System (QMS). While landings since 2007–08 were further affected by the reduction in TACCs for both species in the North Island on 1 Oct. 2007, eel catches have remained below the TACCs as a result of reduced international market demand, and since 2007–08 have ranged between 487 and 642 tonnes. For the period 1991–92 to 2013–14, the North Island provided on average 61% of the total New Zealand eel catch (Table 2).

Table 2: North and South Island eel catch (t) compiled from data from individual processors 1991–92 to 1999–00 and LFRR/QMR/MHR 2000–01 to 2011–12. Numbers in parentheses represent the percentage contribution from the North Island fishery.

Fishing year	North Island	South Island	Total individual processors	LFRR/QMR/MHR Total NZ (excluding Chatham Islands)
1991–92	989	631	1 621 (61%)	_
1992–93	865	597	1 462 (59%)	_
1993–94	744	589	1 334 (56%)	_
1994–95	1 004	510	1 515 (66%)	_
1995–96	962	459	1 481 (65%)	_
1996–97	830	418	1 249 (66%)	_
1997–98	795	358	1 153 (69%)	_
1998–99	804	381	1 185 (68%)	_
1999–00	723	396	1 119 (65%)	_
2000–01	768	303	_	1 071 (72%)
2001–02	644	319	_	962 (67%)
2002–03	507	296	_	803 (63%)
2003–04	454	282	_	737 (62%)
2004–05	426	285	_	712 (60%)
2005–06	497	285	_	781 (64%)
2006–07	440	278	_	718 (61%)
2007–08	372	288	_	660 (56%)
2008–09	303	215	_	517 (59%)
2009–10	318	242	_	560 (57%)
2010–11	330	296	_	626 (53%)
2011–12	418	337	_	755 (55%)
2012–13	364	353	–	717 (51%)
2013–14	367	311	–	678 (54%)
2014–15	306	241	-	547 (56%)

Table 3: Total NZ eel landings (t) by species and fishing year. Numbers in bold represent data collected following the introduction of the ECLR forms, whereas all others are pro-rated as described above. Numbers in parentheses represent the longfin proportion of total landings.

Fishing year	Shortfin (SFE)	Longfin (LFE)	Total landings
1989–90	617	453	1 069 (42%)
1990–91	808	616	1 424 (43%)
1991–92	941	612	1 553 (39%)
1992–93	872	741	1 613 (46%)
1993–94	692	588	1 279 (46%)
1994–95	909	588	1 497 (39%)
1995–96	977	518	1 495 (35%)
1996–97	841	465	1 307 (36%)
1997–98	881	442	1 323 (33%)
1998–99	824	434	1 258 (34%)
1999–00	741	413	1 154 (36%)
2000–01	698	388	1 086 (36%)
2001–02	660	360	1 020 (35%)
2002–03	560	279	839 (33%)
2003–04	510	216	726 (30%)
2004–05	460	254	713 (36%)
2005–06	553	226	774 (29%)
2006–07	520	210	730 (29%)
2007–08	470	196	666 (29%)
2008–09	424	95	519 (18%)
2009–10	441	114	555 (20%)
2010–11	440	159	599 (26%)
2011–12	515	237	752 (32%)
2012–13	491	230	721 (32%)
2013–14	475	201	676 (30%)
2014–15	434	116	550 (21%)

Prior to the 2000–01 fishing year, three species codes were used to record species landed, SFE (shortfin), LFE (longfin) and EEU (eels unidentified). A high proportion of eels (46% in 1990–91) were identified as EEU between the fishing years 1989–90 and 1998–99. Pro-rating the EEU catch by the ratio of LFE : SFE by fishing year provides a history of landings by species (Table 3), although it should be noted that pro-rated catches prior to 1999–00 are influenced by the high proportion of EEU from some eel statistical areas (e.g., Waikato) and therefore may not provide an accurate species breakdown. The introduction of the new Eel Catch Landing Return (ECLR) form in 2001–02 improved the species composition information, as the EEU code was not included. There was a gradual decline in the proportion of longfin eels in landings, from over 40% in 1989–90 to about 30% in 2007–08, followed by a marked drop to 18% in 2008–09 (Table 3). The proportion of longfins in the catch then gradually increased and was about 30% of the total in 2013–14. Several factors have contributed to the pattern in the proportion of longfin eels, including: declining abundance in the early part of the series; reduced quotas; the closure of come catchments to commercial fishing; and declining/fluctuating market demand.

The species proportion of the landings varies by geographical area. From analyses of landings to eel processing factories and estimated catch from ECLRs, longfins are the dominant species in most areas of the South Island, except for a few discrete locations such as lakes Te Waihora (Ellesmere) and Brunner, and the Waipori Lakes, where shortfins dominate landings. Shortfins are dominant in North Island landings. The shortfin eel catches are mostly comprised of pre-migratory female feeding eels, with the exception of Te Waihora (Lake Ellesmere), where significant quantities of seaward migrating male shortfin eels (under 220 g) are taken during the period of February to March.

Table 4: TACCs and commercial landings (t) for South Island eel stocks (based on ECLR data).

Fishing	ANG11		ANG12		ANG13		ANG14		ANG15		ANG16		Total
Year	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	landings
												Shortfin Eel (SFE)	
2000–01	40	4.5	43	4.4	122	102.2	35	6.1	118	19.4	63	9.8	146.6
2001–02	40	18.9	43	5.7	122	63.6*	35	10.1	118	20.2	63	20.2	83.8
2002–03	40	19.2	43	5.9	122	95.4	35	9.9	118	11.7	63	4.5	146.7
2003–04	40	8.7	43	4.8	122	118.2	35	7.5	118	13.0	63	9.4	161.8
2004–05	40	2.7	43	1.4	122	121.3	35	5.7	118	1.5	63	9.6	156.0
2005–06	40	9.0	43	4.3	122	119.9	35	7.4	118	12.0	63	11.2	164.0
2006–07	40	10.9	43	6.3	122	121.5	35	4.4	118	15.4	63	16.5	175.2
2007–08	40	8.5	43	1.2	122	119.7	35	5.8	118	21.2	63	11.5	167.9
2008–09	40	4.7	43	< 1	122	123.0	35	1.8	118	16.6	63	19.7	166.0
2009–10	40	3.8	43	5.8	122	97.3	35	3.9	118	29.1	63	30.3	170.2
2010–11	40	10.0	43	6.9	122	89.3	35	3.7	118	19.4	63	19.9	149.2
2011–12	40	8.8	43	10.8	122	113.3	35	7.3	118	21.4	63	13.1	174.8
2012–13	40	7.6	43	19.9	122	125.0	35	2.6	118	16.7	63	22.8	194.6
2013–14	40	3.4	43	16.5	122	119.3	35	2.5	118	11.7	63	16.8	170.2
2014–15	40	2.8	43	13.6	122	112.1	35	1.3	118	14.4	63	11.8	156.0
												Longfin Eel (LFE)	
2000–01	40	10.6	43	22.6	122	2.1	35	12.6	118	63.6	63	28.4	140.1
2001–02	40	16.4	43	15.6	122	1.0*	35	6.0	118	80.5	63	30.2	150.1
2002–03	40	10.6	43	10.1	122	1.4	35	10.0	118	73.0	63	27.2	132.6
2003–04	40	2.8	43	2.7	122	< 1	35	10.2	118	64.7	63	21.2	102.9
2004–05	40	2.8	43	3.4	122	< 1	35	2.3	118	79.6	63	34.4	123.7
2005–06	40	6.0	43	9.8	122	< 1	35	6.4	118	61.1	63	21.1	105.5
2006–07	40	4.4	43	1.7	122	< 1	35	7.0	118	65.0	63	32.8	112.1
2007–08	40	11.9	43	6.5	122	< 1	35	7.4	118	73.0	63	23.1	122.9
2008–09	40	1.4	43	< 1	122	0	35	2.3	118	33.7	63	13.2	51.0
2009–10	40	8.0	43	< 1	122	< 1	35	3.2	118	40.0	63	15.3	68.0
2010–11	40	13.1	43	6.1	122	< 1	35	6.7	118	73.9	63	14.1	114.9
2011–12	40	11.2	43	11.0	122	2.0	35	18.4	118	85.4	63	27.6	155.7
2012–13	40	15.6	43	7.6	122	<1	35	22.3	118	88.6	63	30.4	164.5
2013–14	40	14.0	43	6.1	122	<1	35	10.7	118	77.9	63	29.3	138.5
2014–15	40	2.5	43	3.7	122	0	35	2.1	118	56.3	63	15.3	79.9

*For the transition from a 1 0ctober to 1 February fishing year, an interim TACC of 78 t was set for the period 1 October 2001 to 31 January 2002. From January 2002 the Te Waihora (Lake Ellesmere) fishing year was 1 February to 31 January. Fishing year for all other areas is 1 October to 30 September.

Table 5: TACCs and commercial landings (t) for Chatham Island (SFE 17) and North Island shortfin stocks from 2003–04 to 2014–15 (based on ECLR data).

Fishing	SFE 17		SFE 20		SFE 21		SFE 22		SFE 23		Total
Year	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	landings
2003–04	10	< 1	-	-	-	-	-	-	-	-	-
2004–05	10	1.6	149	78.4	163	122.6	108	80.0	37	15.7	298
2005–06	10	2.6	149	92.0	163	143.3	108	106.7	37	29.9	374
2006–07	10	< 1	149	108.5	163	113.3	108	92.9	37	29.8	345
2007–08	10	0	86	77.5	134	126.7	94	81.6	23	15.3	301
2008–09	10	0	86	67.7	134	110.4	94	70.1	23	10.2	258
2009–10	10	< 1	86	62.0	134	121.7	94	69.1	23	18.1	271
2010–11	10	< 1	86	83.0	134	132.4	94	59.1	23	16.1	290
2011–12	10	< 1	86	85.4	134	139.7	94	94.8	23	20.6	340.4
2012–13	10	<1	86	77.4	134	124.8	94	79.9	23	14.5	296.6
2013–14	10	<1	86	70.2	134	138.2	94	82.2	23	13.9	304.5
2014–15	10	0	86	64.9	134	125.5	94	73.7	23	13.7	277.8

The Total Allowable Commercial Catch (TACC) and reported commercial landings by species for the South Island eel stocks are shown in Table 4 from 2000–01 (when eels were first introduced into the QMS) to 2014–15. The annual landings are based on data recorded on ECLR forms, as the MHR forms report QMA catches for the two species combined.

The TACCs and commercial landings for the Chatham Island and North Island shortfin and longfin eel stocks are shown in Tables 5 and 6. The Chatham Island and North Island fisheries were first introduced into the QMS in 2003–04 and 2004–05, respectively. Note that from 1 October 2007 the TACCs were markedly reduced for all North Island shortfin and longfin stocks .

Table 6: TACCs and commercial landings (t) for Chatham Island (LFE 17) and North Island longfin stocks from 2003–04 to 2014–15 (based on ECLR data).

Fishing	LFE 17		LFE 20		LFE 21		LFE 22		LFE 23		Total
Year	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	landings
2003–04	1	< 1	-	-	-	-	-	-	-	-	-
2004–05	1	< 1	47	27.1	64	52.9	41	23.6	41	26.4	130.0
2005–06	1	< 1	47	24.4	64	39.2	41	29.6	41	22.3	115.5
2006–07	1	0	47	27.0	64	30.4	41	25.7	41	14.9	98.0
2007–08	1	0	19	18.1	32	30.9	21	18.0	9	6.5	74.0
2008–09	1	0	19	11.5	32	22.5	21	7.3	9	2.5	44.0
2009–10	1	< 1	19	9.4	32	21.7	21	10.5	9	5.7	47.0
2010–11	1	< 1	19	12.3	32	16.7	21	8.0	9	7.4	44.0
2011–12	1	< 1	19	19.2	32	32.5	21	18.5	9	6.6	76.8
2012–13	1	<1	19	17.9	32	26.0	21	17.2	9	5.6	66.7
2013–14	1	0	19	14.9	32	26.6	21	15.6	9	5.2	62.3
2014–15	1	0	19	10.4	32	10.1	21	12.1	9	3.3	35.9

1.2 Recreational fisheries

In October 1994, a recreational individual daily bag limit of six eels was introduced throughout New Zealand. There is no quantitative information on the recreational harvest of freshwater eels. The recreational fishery for eels includes any eels taken by people fishing under the amateur fishing regulations and includes any harvest by Maori not taken under customary provisions. The extent of the recreational fishery is not known although the harvest by Maori might be significant.

1.3 Customary non-commercial fisheries

Eels are an important food source for use in customary Maori practices. Maori developed effective methods of harvesting, and hold a good understanding of the habits and life history of eels. Fishing methods included ahuriri (eel weirs), hinaki (eel pots) and other methods of capture. Maori exercised conservation and management methods, which included seeding areas with juvenile eels and imposing restrictions on harvest times and methods. The customary fishery declined after the 1900s but in many areas Maori retain strong traditional ties to eels and their harvest.

In the South Island, Lake Forsyth (Waiwera) and its tributaries have been set aside exclusively for Ngai Tahu. Other areas, such as the lower Pelorus River, Taumutu (Te Waihora), Wainono Lagoon and its catchment, the Waihao catchment, the Rangitata Lagoon and the Ahuriri Arm of Lake Benmore, have been set aside as non-commercial areas for customary fisheries. Mätaitai Reserves covering freshwater have been established in the South Island on the Mataura River, Okarito Lagoon, Waihao River (including Wainono Lagoon and parts of Waituna Stream and Hook River), Lake Forsyth and the Waikawa River. Commercial fishing is generally prohibited in mätaitai reserves. In the North Island, commercial fishing has been prohibited from the Taharoa lakes, Whakaki Lagoon, Lake Poukawa and the Pencarrow lakes (Kohangapiripiri and Kohangatera) and associated catchments.

Table 7: TACs, and customary non-commercial and recreational allowances (t) for South Island eel stocks. Note that an allowance for other sources of fishing-related mortality has not been set.

	ANG 11 Nelson/ Marlborough	ANG 12 North Canterbury	ANG 13 Te Waihora Lake Ellesmere	ANG 14 South Canterbury	ANG 15 Otago/Southland	ANG 16 West Coast
TAC	51	55	156	45	151	80
Customary Non-Commercial Allowance	10	11	31	9	30	16
Recreational Allowance	1	1	3	< 1	3	2

Table 8: TACs, and customary non-commercial, recreational, and other fishing-related mortality allowances (t) for the Chatham Island and North Island shortfin stocks. Numbers in parentheses reflect the current TACs following a review of catch limits for October 2007 for all North Island eel stocks.

	SFE 17	SFE 20	SFE 21	SFE 22	SFE 23
TAC	15	211 (148)	210 (181)	135 (121)	50 (36)
Customary Non-Commercial Allowance	3	30	24	14	6
Recreational Allowance	1	28	19	11	5
Other fishing-related mortality	1	4	4	2	2

Customary non-commercial fishers desire eels of a greater size, i.e. over 750 mm and 1 kg. Currently, there appears to be a substantially lower number of larger eels in the main stems of some major river catchments throughout New Zealand, which may limit customary fishing. Consequently the access to eels for customary non-commercial purposes has declined over recent decades in many areas. There is no overall assessment of the extent of the current or past customary non-commercial take. For the introduction of the South Island eel fishery into the QMS, an allowance was made for customary non-commercial harvest. It was set at 20% of the TAC for each QMA, equating to 107 t (Table 7). For the introduction of the North Island fishery into the QMS, the customary non-commercial allowance was set at 74 t for shortfins and 46 t for longfins (Tables 8 and 9). For the Chatham Islands, the customary non-commercial allowance was 3 t for shortfin and 1 t for longfin eels (Tables 8 and 9).

Eels may be harvested for customary non-commercial purposes under an authorisation issued under fisheries regulations. Such authorisations are used where harvesting is undertaken beyond the recreational rules. The majority of the South Island customary harvest comes from QMAs ANG 12 (North Canterbury) and ANG 13 (Te Waihora/Lake Ellesmere). Customary regulations were only extended to freshwaters of the Chatham and North Islands in November 2008.

Table 9: TACs, and customary non-commercial, recreational, and other mortality allowances (t) for the Chatham Island and North Island longfin eel fisheries. Numbers in parentheses reflect the current TACs following a review of catch limits for October 2007 for all North Island eel stocks.

	LFE 17	LFE 20	LFE 21	LFE 22	LFE 23
TAC	3	67 (39)	92 (60)	54 (34)	66 (34)
Customary Non-Commercial Allowance	1	10	16	6	14
Recreational Allowance	1	8	10	5	9
Other fishing-related mortality	0	2	2	2	2

1.4 Illegal catch

There is no information available on illegal catch. There is some evidence of fishers exceeding the amateur bag limit, and some historical incidences of commercial fishers operating outside of the reporting regime, but overall the extent of any current illegal take is not considered to be significant.

1.5 Other sources of mortality

Although there is no information on the level of fishing-related mortality associated with the eel fishery (i.e., how many eels die while in the nets), it is not considered to be significant given that the fishing methods used are passive and catch eels in a live state.

Eels are subject to significant sources of mortality from non-fishing activities, although this has not been quantified. Direct mortality occurs through the mechanical clearance of drainage channels, and damage by hydro-electric turbines and flood control pumping (Beentjes et al 2005). Survival of eels through hydroelectric turbines is affected by eel length, turbine type and turbine rotation speed. The mortality of larger eels (specifically longfin females), is estimated to be 100%. Given the large number of eels in hydro lakes, this source of mortality could be significant and reduce spawner escapement from New Zealand. Mitigation activities such as trap and transfer of downstream migrants, installation of downstream bypasses and spillway opening during runs, is expected to have reduced this impact at those sites where such measures have been implemented. In addition to these direct sources of mortality, eel populations are likely to have been significantly reduced since European settlement from the 1840s by wetland drainage (wetland areas have been reduced by up to 90% in some areas), and on-going habitat modification brought about by irrigation, channelisation of rivers and streams and the reduction in littoral habitat. On-going drain maintenance activities by mechanical means to remove weeds may cause direct mortality to eels through physical damage or by stranding and subsequent desiccation.

2. BIOLOGY

Species and general life history

There are 16 species of freshwater eel worldwide, with the majority of species occurring in the Indo-Pacific region. New Zealand freshwater eels are regarded as temperate species, similar to the Northern Hemisphere temperate species, the European eel *A. anguilla*, the North American eel *A. rostrata*, and the Japanese eel *A. japonica*. Freshwater eels have a life history unique among fishes that inhabit New Zealand waters. All *Anguilla* species are faciltative catadromous, living predominantly in freshwater and undertaking a spawning migration to an oceanic spawning ground. They spawn once and then die (i.e., are semelparous). The major part of the life cycle is spent in freshwater or estuarine/coastal habitat. Spawning of New Zealand species is presumed to take place in the southwest Pacific. Progeny undertake a long oceanic migration to freshwater where they grow to maturity before migrating to the oceanic spawning grounds. The average larval life is 6 months for shortfins and 8 months for longfins.

The longfin eel is endemic to New Zealand and is thought to spawn east of Tonga. The shortfin eel is also found in South Australia, Tasmania, and New Caledonia; spawning is thought to occur northeast of Samoa. Larvae (leptocephali) are transported to New Zealand largely passively on oceanic surface currents, and the metamorphosed juveniles (glass eels) enter freshwater from August to November. The subsequent upstream migration of elvers (pigmented juvenile eels) in summer distributes eels throughout the freshwater habitat. The two species occur in abundance throughout New Zealand and have overlapping habitat preferences with shortfins predominating in lowland lakes and slow moving soft bottom rivers and streams, while longfins prefer fast flowing stony rivers and are dominant in high country lakes.

Growth

Age and growth of New Zealand freshwater eels was reviewed by Horn (1996). Growth in freshwater is highly variable and dependent on food availability, water temperature and eel density. Eels, particularly longfins, are generally long lived. Maximum recorded age is 60 years for shortfins and 106 years for longfins. Ageing has been validated (e.g. Chisnall & Kalish, 1993). Growth rates determined from the commercial catch sampling programme (1995–97) indicate that in both the North and South Islands, growth rates are highly variable within and between catchments. Shortfins often grow considerably faster than longfins from the same location, although in the North Island longfins grow faster than shortfins in some areas (e.g. parts of the Waikato catchment). South Island shortfins take, on average, 12.8 years (range 8.1–24.4 years) to reach 220 grams (minimum legal size), compared with 17.5 years (range 12.2–28.7 years) for longfins, while in the North Island the equivalent times are 5.8

years (3–14.1 years) and 8.7 years (range 4.6–14.9 years) respectively. Australasian longfin growth is generally greater than that of New Zealand longfins, and closer to that of shortfins.

Growth rates (in length) are usually linear. Sexing immature eels is difficult, but from length at age data for migratory eels, there appears to be little difference in growth rate between the sexes. Sex determination in eels appears to be influenced by environmental factors and by eel density, with female eels being more dominant at lower densities. Age at migration may vary considerably between areas depending on growth rate. Males of both species mature and migrate at a smaller size than females. Migration appears to be dependent on attaining a certain length/weight combination and condition. The range in recorded age and length at migration for shortfin males is 5–22 years and 40–48 cm, and for females 9–41 years and 64–80 cm. For longfinned eels the range in recorded age and length at migration is 11–34 years and 48–74 cm for males, and 27–61 years and 75–158 cm for females. However because of the variable growth rates, eels of both sexes and species may migrate at younger or older ages.

Recruitment

The most sensitive measure of recruitment is monitoring of glass eels, the stage of arrival from the sea. In the Northern Hemisphere where glass eel fisheries exist, catch records provide a long term time series that is used to monitor eel recruitment. In the absence of such fisheries in New Zealand, MPI has taken the unique opportunity that exists to monitor the relative abundance of elvers arriving at large in-stream barriers, where established elver trap and transfer programmes operate. Provided that the data are collected in a consistent manner every year, these data can be used to provide an index of eel recruitment into New Zealand's freshwaters.

Although New Zealand has a small dataset of elver catch data compared to Asian, European and North American recruitment records, including the 2014–15 season, there are now up to 20 years of reliable and accurate elver catch information for some sites (Martin et al In press). These records show that the magnitude of the elver catches varies markedly between sites and that there are large variations in catches between seasons at all the sites (Table 10a). Whilst the majority of this variability is likely to be caused by natural oceanic and climatic influences, some is due to changes in fishing effort, technological advances and recording procedures. Consequently, a number of existing records need to be excluded from recruitment trend analyses.

Because of the variability between sites and years, elver catch records were normalised following the method of Durif et al (2008), and a "normal" catch index was calculated for each species, season, and location. The normalised catch index (Xij) is calculated as follows:

$$X_{i,j} = (x_{i,j} - \mu_j)/\sigma_j$$

Where:

$x_{i,j}$ = elver catch for a season

μ_j = mean elver catch at a site for all seasons

σ_j = standard deviation of elver catch at a site for all seasons.

Although several of the sites show that catches peaked during the 2007–08 and 2008–09 migration seasons this is not consistent across all sites and also varies slightly between shortfins and longfins. A trend of increasing catches at Piripaua, however, stand out at present (Figure 2a).

Variation in the distance of dam sites from the sea and possibly differences in migration rates and growth rate between rivers has resulted in some variability in the size (age) structure of elvers captured at the monitored sites. Consequently the median ages of elvers at key sites were determined from examination of otoliths extracted from elvers captured during the 2013–14 season (Table 10b). The median ages were then used to standardise the normalised catch index so that it reflected the relative recruitment of glass eels (0 yrs old) into each catchment.

The standardised recruitment indices indicate that there was a recruitment peak for both shortfins and longfins in the Waikato, Mokau, Patea and Grey rivers around 2006–2007 (Figure 2b). A recruitment peak also occurred at the same time on the Rangitaiki River which, unlike the other four rivers, is on the East Coast.

The Waikato and Northern Wairoa rivers and possibly the Patea River on the West Coast and the Rangitaiki and Wairoa rivers on the East Coast of the North Island all show an increased recruitment of shortfins around 2011 and 2012. In the South Island the Grey River on the West Coast and the Waitaki River on the East Coast also showed increased recruitment of shortfins in 2012 (Figure 2b). Because of the time it takes for longfins to reach these two South Island dams it is still too early to know if longfin recruitment also increased in 2011 and 2012.

The Wairoa and Waiau rivers do not follow the general patterns shown by other sites. Issues with inconsistent fishing effort in the past most likely have disguised the actual recruitment trend for the Waiau River (Figure 2b).

Since the early 1990s there have been four peaks of the average recruitment index for shortfins (1996, 2001, 2006 and 2013) and longfins (1996, 2000, 2006 and 2012) (Figure 2b). The length of time between these peaks varies from four to seven years, indicating a short-term cycle that appears to be influencing recruitment of both species.

Eel larvae are thought to not only actively swim but also use sea currents to reach the New Zealand continental shelf. Examination of regional differences in glass eel mean size and condition indicated an arrival pattern from the north in an anti-clockwise dispersal pattern around New Zealand (Chisnall et al. 2002).

There is evidence from duration of runs and catch-effort data that glass eel runs may now be smaller in the Waikato River than in the 1970s (Jellyman et al 2009). However, studies on the variability and temporal abundance of glass eels over a seven year period from 1995 to 2002 at five sites showed no decline in recruitment for either species (Jellyman & Sykes 2004). At these same sites the density of shortfin glass eels exceeded that of longfins for any one year but the annual trends for both species were generally similar (Jellyman et al 2002).

There is some evidence of annual variation influenced by the El Nino Southern Oscillation (ENSO), with the arrival route of glass eels from the northwest being stronger during the La Nina phase and stronger from the northeast during the El Nino phase (Chisnall et al 2002). This may also explain the recruitment pattern seen in the elver trap and transfer programmes (Martin et al 2014). A greater understanding of sea currents, notably along the coastline, and their effects on recruitment patterns, together with longer catch records, particularly from the east coast (e.g., Waitaki and Roxburgh dams), may further elucidate recruitment trends and drivers.

Spawning

As eels are harvested before spawning, the escapement of sufficient numbers of eels to maintain a spawning population is essential to maintain recruitment. For shortfin eels the wider geographic distribution for this species (Australia, New Zealand, southwest Pacific) means that spawning escapement occurs from a range of locations throughout its range. In contrast, the more limited distribution of longfin eels (New Zealand and offshore islands) means that the spawning escapement must occur from New Zealand freshwaters and offshore islands.

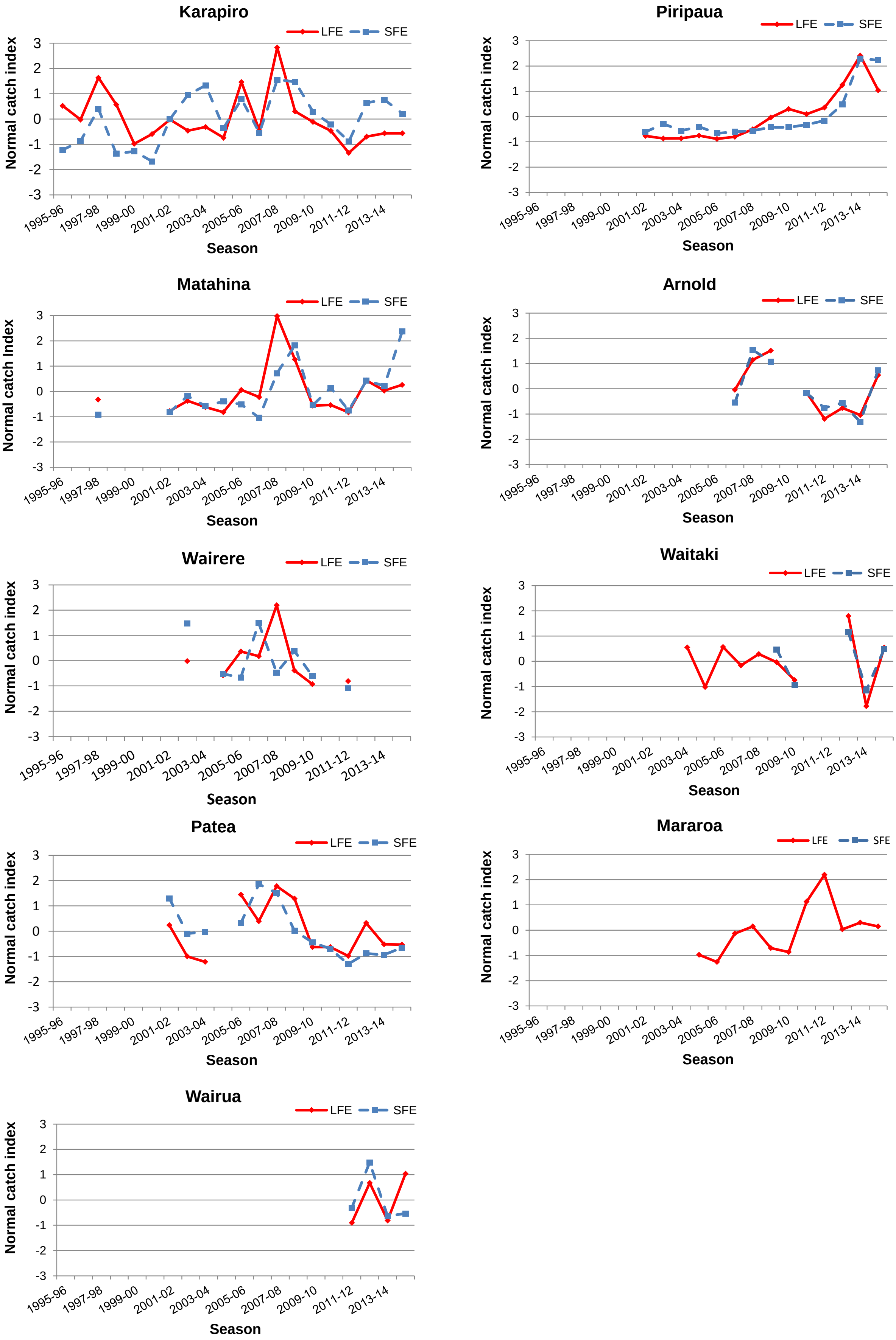


Figure 2a: Normal catch index for longfin (LFE) and shortfin (SFE) elvers at monitored sites from 1995–96 to 2014–15. (Notes: incomplete records for season have been omitted; 0 = mean index for entire monitoring period for each site; few shortfins recorded at Mararoa Weir). Mararoa has inconsistent fishing effort so the trend shown may reflect increased trapping efficiency rather than increased recruitment.

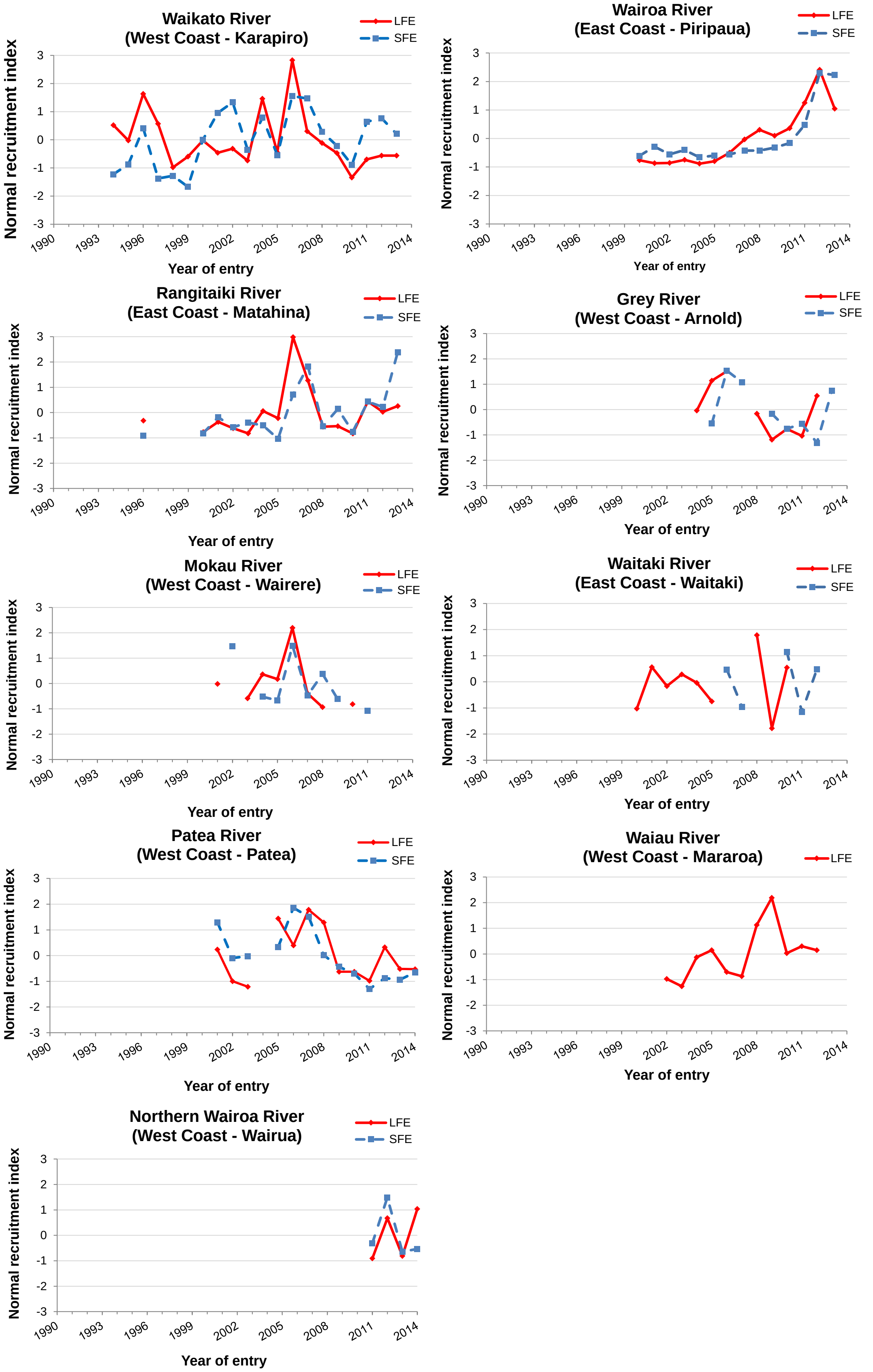


Figure 2b: Normal recruitment indices for longfin (LFE) and shortfin (SFE) elvers at the main monitored sites from 1995–96 to 2014–15 (0 = mean catch for entire monitoring period for each site). Mararoa has inconsistent fishing effort so the trend shown may reflect increased trapping efficiency rather than increased recruitment.

Table 10a: Estimated numbers (1000s) of all elvers and, in brackets, longfins only; trapped at key elver trap and transfer monitoring sites by season (Dec–April) 1992–93 to 2013–14. Shaded cells indicate seasons when the records are considered unsuitable for trend analysis (monitoring disruption, flood damage etc.). N/A = no species composition. (From Martin et al. In press and NIWA unpublished records.).

Year	Wairua	Karapiro	Matahina	Wairere	Patea	Piripaua	Arnold	Waitaki	Roxburgh	Mararoa
1992–93		92	> 32							
		(31)	(>2)							
1993–94		518	> 215							
		(176)	(NA)							
1994–95		282	> 39							
		(96)	(NA)							
1995–96		1 155	> 144							
		(333)	(NA)							
1996–97		1 220	14			2.1			0.3	
		(246)	(4)			(1)				
1997–98		2 040	615			7.3			11	
		(510)	(136)			(NA)				
1998–99		1 097	1 002			3.1			7.4	43
		(341)	(NA)			(0.4)				(43)
1999–00		892	2 001	166	461	2.6				90
		(94)	(NA)	(NA)	(NA)	(<0.1)				(90)
2000–01		782	2 054	191	495	6				28
		(155)	(NA)	(NA)	(NA)	(0.2)				(28)
2001–02		1 596	619	130	754	4.1			1	NA
		(246)	(27)	(NA)	(48)	(0.4)				
2002–03		1 942	1 484	289	380	10.2		<0.1	0.1	36
		(176)	(124)	(22)	(8)	(0.2)		(<0.1)		(36)
2003–04		2 131	945	330	391	4.9		4.6	1.4	98
		(200)	(64)	(NA)	(1)	(0.2)		(4.6)		(98)
2004–05		1 333	1 117	155	450	8.1	27	1.5		64
		(132)	(15)	(13)	(NA)	(0.5)	(7)	(1.5)		(64)
2005–06		2 178	1 193	163	562	2.8	14	4.7		46
		(483)	(228)	(28)	(87)	(0.1)	(8)	(4.7)		(46)
2006–07		1 296	485	294	896	4.2	107	3.3		118
		(179)	(159)	(25)	(53)	(0.3)	(52)	(3.3)		(118)
2007–08		2 728	3 378	204	857	5.7	186	4.1		133
		(701)	(928)	(57)	(98)	(1.1	(78)	(4.1)		(133)
2008–09		2 288	4 307	216	480	9.5	183	4.7		81
		(298)	(517)	(16)	(82)	(2.2)	(87)	(3.5)		(81)
2009–10		1 708	1 002	146	309	10.3	20	2.4		71
		(232)	(78)	(7)	(20)	(2.9)	(5)	(2.1)		(71)
2010–11		1 434	1 841	227	247	11.8	114	2.9		198
		(175)	(84)	(NA)	(20)	(2.5)	(49)	(2.4)		(198)
2011–12	3 178	1 003	641	119	72	15.6	76	7	NA	266
	(11)	(36)	(15)	(0.5)	(6.8)	(3.1)	(26)	(5.8)	(NA)	(266)
2012–13	5 488	1 771	2 421	182	74	33	90	8.9	14	128
	(98)	(139)	(317)	(NA)	(16)	(5.2)	(36)	(7.1)	(14)	(128)
2013–14	2 780	1 843	2 068	193.1	193.2	68.7	65.3	0.2	0.8	150.4
	(16.2)	(160)	(220)	(NA)	(23.5)	(7.9)	(29.4)	(0.1)	(0.8)	(150.4)
2014–15	3 010	1 604	4 736	241.9	260.6	61.2	152.5	6.0	1.3	135.6
	(118)	(160)	(275)	(NA)	(23.1)	(4.7)	(65)	(4.6)	(1.3)	(135.5)

Table 10b: Summary of elver weights, lengths and estimated ages at sites where individual weights and lengths of 100 SFE and 100 LFE (if available) were measured monthly during 2013–14 (from Martin et al. In press).

Location	Species	n	Length (mm)			Weight (g)			Estimated age[a]
			Mean	Median	Range	Mean	Median	Range	
Wairua Falls	LFE	7	60	59	66–55	0.24	0.22	0.35–0.17	–[b]
	SFE	1 318	63	61	130–48	0.26	0.22	1.67–0.07	0
Karapiro	LFE	140	106	104	157–75	1.60	1.3	5.2–0.5	1
	SFE	295	93	91	153–74	0.9	0.8	3.9–0.4	1
Matahina	LFE	272	111	110	152–86	1.53	1.4	4.0–0.6	1
	SFE	750	97	96	133–75	0.96	0.9	2.9–0.4	1
Piripaua	LFE	166	115	112	188–90	1.7	1.5	8.7–0.8	1
	SFE	497	101	100	142–85	1.1	1.1	3.4–0.5	1
Patea	LFE	124	80	79	124–59	0.62	0.56	2.57–0.18	0
	SFE	1 247	74	73	121–57	0.46	0.43	1.95–0.16	0
Arnold	LFE	400	130	126	202–101	2.1	1.8	8.9–0.7	2
	SFE	418	111	108	175–90	1.1	1.0	4.3–0.5	1
Waitaki	LFE	53	196	200	260–118	10.0	8.65	22.1–1.7	4
	SFE	103	132	130	203–102	2.25	1.98	11.3–0.9	2
Roxburgh	LFE	16	159	163	210–120	4.38	4.34	7.5–2.3	–[b]
Mararoa Weir	LFE	1 591	152	137	240–92	4.9	3.0	18.92–0.7	2
	SFE	15	108	104	150–92	1.34	0.99	3.8–0.6	–[b]

[a] Fresh water age based on median lengths of elver at each site and nation-wide age vs length regression.
[b] Insufficient number of elvers measured to accurately determine age distribution.

3. STOCKS AND AREAS

The lifecycle of each species has not been completely resolved but evidence supports the proposition of a single (panmictic) stock for each species. Biochemical evidence suggests that shortfins found in both New Zealand and Australia form a single biological stock. Longfins are endemic to New Zealand and are assumed to be a single biological stock.

Within a catchment, post-elver eels generally undergo limited movement until their seaward spawning migration. Therefore once glass eels have entered a catchment, each catchment effectively contains a separate population of each eel species. The quota management areas mostly reflect a combination of these catchment areas.

Shortfin and longfin eels have different biological characteristics in terms of diet, growth, maximum size, age of maturity, reproductive capacity, and behavioural ecology. These differences affect the productivity of each species, and the level of yield that may be sustainable on a longer term basis, as well as their interactions with other species. In order that catch levels for each species are sustainable in the longer term, and the level of removals does not adversely affect the productivity of each species, it is appropriate that the level of removals of each species is effectively managed.

4. STOCK ASSESSMENT

There is no formal stock assessment available for freshwater eels. Fu et al (2012) recently developed a length-structured longfin population model that generated New Zealand-wide estimates of the pre-exploitation female spawning stock biomass (approximately 1700 t) as well as the pre-exploitation biomass of legal-sized eels (16 000 t in all fished areas and 6000 t in protected areas). By contrast, the model estimated current female spawning stock biomass to be approximately 55% of pre-exploitation levels, whereas the current biomass of legal-sized eels ranged from 20% to 90% of the pre-exploitation level for the fished areas. However, the Working Group did not accept the assessment and noted that further analyses were necessary to investigate the models underlying assumptions; given that the results were strongly driven by estimates of longfin commercial catches from individual eel statistical areas as well as GIS-based estimates of recruitment.

4.1 Size/age composition of commercial catch

Catch sampling programmes sampled commercial eel landings throughout New Zealand over three consecutive years between 1995–96 and 1997–98, and then in 1999–2000 and 2003–04 (Beentjes 2005, Speed et al 2001). Sampling provided information on the length and age structure, and sex composition of the commercially caught eel populations throughout the country, and indicated a high degree of variability within and among catchments.

The commercial eel monitoring programme collects processor recorded data for each species based on size-grades (market determined; two to three grades) and catch location (eel statistical sub-area; catchment based), from virtually all commercial landings throughout New Zealand. This programme began in 2003–04 in the North Island and 2010–11 in the South Island (Beentjes 2013) and is ongoing.

4.2 Catch-per-unit-effort analyses

Each species of eel comprises a single stock, and these can be more appropriately managed using an alternative to the maximum sustainable yield (*MSY*) approach, which is available under s.14 of the Fisheries Act 1996. To that end, standardised catch-per-unit-effort (CPUE) analyses have been conducted for the commercial shortfin and longfin eel fisheries by Eel Statistical Area (ESA; Table 11 and Figure 3) from 1990–91 to 2011–12 for all North Island ESAs and from 1990–91 to 2012–13 for all South Island ESAs (Tables 12 to 13 and Figures 4–7).

North Island CPUE

In general CPUE for North Island shortfin, with the exception of Northland (ESA AA) where CPUE steadily increased throughout the time series, either initially declined or there were no trends, followed by strong increases, beginning from 2002 to 2007 (Table 12, Figure 4) (Beentjes & Dunn 2013b).

For longfin there were generally fewer data than for shortfin for most areas and indices were often more variable or associated with wider confidence intervals. In general, apart from Rangitikei-Whanganui (ESA AH) which showed a steadily declining CPUE trend throughout the time series, CPUE initially declined, and then was either flat with no clear trend or there was an increase in CPUE between 2005 and 2011. Most increases in CPUE were only slight (Table 13, Figure 5) (Beentjes & Dunn 2013b). Several factors may have resulted in conservative estimates of North Island longfin eel CPUE, especially after 2005–06:

1. The unrecorded return of small and medium sized longfin eels to the water. This became more prevalent after the substantial reduction in NI longfin quotas in 2007–08, as many fishers do not have ACE to cover all of their catch (larger longfins are more valuable than small and medium specimens). Industry were previously unaware of the fact that eels of legal size (220 g–4 kg) that are released are supposed to be recorded using the destination X code. CPUE of the large commercial size category of longfin eels, as previously recommended by the WG, would not be affected by this behaviour. CPUE of the large size category will be investigated when the North Island CPUE series are next updated.
2. The introduction of a maximum size of 4kg in 2007–08. Longfins > 4 kg were landed before this date. There is currently no legal requirement to record the catch of eels > 4 kg.
3. Avoidance of longfin habitat post 2006–07 in some statistical areas as there is currently insufficient quota to allow targeting of longfin eels. The QMA most affected is LFE 23 (current TACC is 9 tons). Almost all of the longfin TACC is leased to a fisher operating in the Taranaki statistical area of this QMA, leaving very little for the Wanganui-Rangitikei statistical area. The fisher in the latter statistical area consequently targets shortfin eels in farm dams, dune lakes and the lower reaches of some rivers; thereby avoiding high longfin eel catch rates in the Rangitikei River.
4. Voluntary uptake of larger escape tubes (31mm) over the last two years (2010–11 and 2011–12) is expected to have resulted in a stepped drop in CPUE.

Table 11: New Zealand Eel Statistical Areas (ESAs). Areas were given a numeric designation prior to Oct. 2001, at which point letter codes were assigned.

ESA	Letter code	Numeric code
Northland	AA	1
Auckland	AB	2
Hauraki	AC	3
Waikato	AD	4
Bay of Plenty	AE	5
Poverty Bay	AF	6
Hawke Bay	AG	7
Rangitikei-Wanganui	AH	8
Taranaki	AJ	9
Manawatu	AK	10
Wairarapa	AL	11
Wellington	AM	12
Nelson	AN	13
Marlborough	AP	14
South Marlborough	AQ	14
Westland	AX	15
North Canterbury	AR	16
South Canterbury	AT	17
Waitaki	AU	18
Otago	AV	19
Southland	AW	20
Te Waihora (outside-migration area)	AS1	21
Te Waihora migration area	AS2	21
Chatham Islands	AZ	22
Stewart Island	AY	23

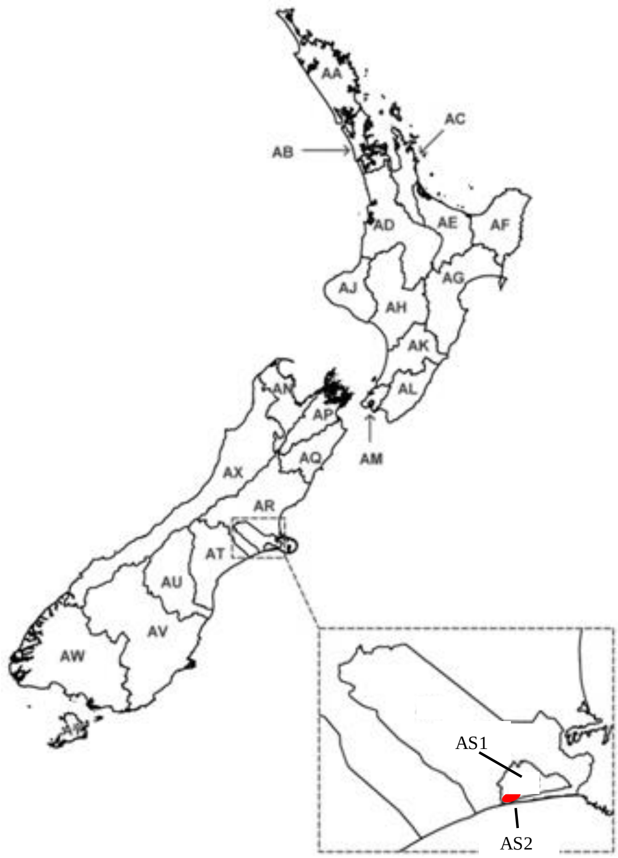


Figure 3: New Zealand Eel Statistical Areas (ESAs).

South Island CPUE

The Eel Working Group (EELWG-2012-05) made the decision to split South Island CPUE analyses into pre- and post-QMS time series with post-QMS CPUE analyses only required for areas with sufficient data and fishers (ESAs: Westland AX, Otago AV, Southland AW). This was done because many fishers fishing under existing permits pre QMS obtained their own quota and entered the fishery as "new" entrants when the QMS was introduced. Fishing coefficients for existing permit holders were therefore likely to have changed considerably after the QMS was introduced. It is not possible to separate catches in the pre-QMS data into individual fisher catch and effort , as was done in the North Island analysis, as the CELR forms used up to 2001–02 included only a field for permit holder, with no way of identifying individual operators. This problem was solved in 2001–02 with the introduction of the new ECER form by adding a field which identified the fisher (i.e.,"catcher") filling out the form.

Table 12: CPUE indices for shortfin eels by Eel Statistical Area (ESA). For the South Island separate indices are presented for pre-QMS (1991–2000) and post-QMS (2001–2010). Fishing years are referred to by the second year (e.g., 1990–91 is referred to as 1991). - insufficient data; –, no analysis. (See Table 11 for ESA area names).

	Shortfin (North Island ESAs)									
Year	AA	AB	AC	AD	AE	AG	AH	AJ	AK	AL
1991	0.75	1.32	0.95	1	1.24	1.51	0.82	1.37	2.7	1.56
1992	0.7	0.83	0.91	1.16	0.83	1.54	0.75	1.48	4.8	1.62
1993	0.75	0.73	1.09	1.11	0.72	1.45	0.83	0.58	2.12	0.93
1994	0.68	0.85	1.04	1.22	0.83	1.37	0.94	0.53	0.67	1.2
1995	0.85	1	1.08	1.19	1.05	1.4	0.88	0.93	0.63	1.12
1996	0.9	1.09	1.11	1.21	1.17	1.06	1.37	0.92	0.52	0.94
1997	0.85	0.82	0.79	1.03	0.92	0.83	0.94	0.7	0.51	0.67
1998	1.05	1.03	0.71	1.1	0.57	0.66	0.89	0.82	0.71	0.91
1999	1.11	1.3	0.76	0.96	0.91	0.94	0.93	1.09	1.03	0.87
2000	1.2	0.95	0.88	0.81	0.49	0.8	0.73	0.95	0.6	0.71
2001	1.22	0.87	0.84	0.77	0.54	1.05	0.8	0.83	0.65	0.88
2002	0.97	0.69	1.13	0.79	0.42	0.54	0.61	0.84	0.77	0.48
2003	0.97	0.75	0.98	0.72	0.63	0.57	0.86	0.72	0.39	0.49
2004	1.01	0.82	1.08	0.89	0.72	0.75	0.4	0.71	1.39	0.36
2005	0.98	0.88	1	0.88	1.25	0.8	0.68	0.68	1.03	1.22
2006	1.03	0.99	1.04	0.96	1.24	1.08	1.23	1.11	1.17	1.14
2007	1.11	1.03	0.93	0.99	1.33	0.91	1.27	0.89	1.34	1.29
2008	1.14	1.36	0.96	1.03	1.6	0.96	1.62	1.3	1.49	1.5
2009	1.18	1.11	1.09	1.12	1.89	1.19	1.7	1.52	1.01	1.32
2010	1.42	1.31	1.11	1.18	1.89	1.23	1.6	2.16	1.2	1.58
2011	1.32	1.5	1.35	1.19	2.2	1.14	2	1.76	1.06	1.7
2012	1.29	1.29	1.51	0.97	2.11	1.17	1.93	1.78	0.89	1.27

		Shortfin (South Island ESAs)								
QMS status	Year	AN	AP_AQ	AR	AT	AU	AV	AW	AX	AS1
Pre-QMS	1991	-	2.36	1.13	2.09	1.7	1.51	1.3	0.96	–
	1992	–	1.94	1.09	1.07	1.46	1.2	1.03	0.61	–
	1993	1.24	1.59	0.94	0.84	0.69	1.05	0.99	1.07	–
	1994	-	1.34	1.01	1.01	1.06	1.03	1.33	0.95	–
	1995	1.16	1.14	0.81	0.79	0.84	0.92	1.01	0.9	–
	1996	0.89	0.65	0.98	0.97	1.31	0.87	0.88	0.85	–
	1997	0.41	0.55	0.97	0.85	0.85	0.9	0.79	0.75	–
	1998	0.97	0.38	1	1.07	1.1	0.84	0.89	1.31	–
	1999	1.37	0.73	1.13	0.67	0.61	0.83	0.9	1.52	–
	2000	1.43	0.91	0.99	1.13	0.88	1.02	1.01	1.48	–
Post-QMS	2001	–	–	–	–	–	–	–	–	–
	2002	–	–	–	–	–	0.86	0.68	0.81	0.37
	2003	–	–	–	–	–	0.86	0.61	0.73	0.42
	2004	–	–	–	–	–	0.76	0.91	0.87	0.51
	2005	–	–	–	–	–	1.05	1.03	0.99	0.58
	2006	–	–	–	–	–	0.89	0.83	0.87	0.79
	2007	–	–	–	–	–	1.21	1.07	0.99	1.17
	2008	–	–	–	–	–	0.8	1.29	0.89	1.28
	2009	–	–	–	–	–	1.26	0.8	1.49	1.31
	2010	–	–	–	–	–	1.27	1.23	1.16	1.17
	2011						1.34	1.35	1.16	2.34
	2012						1.12	1.26	1.11	2.29
	2013						0.81	1.34	1.16	2.23

Table 13: CPUE indices for longfin eels by Eel Statistical Area (ESA). For the South Island separate indices are presented for pre–QMS (1991–2000) and post QMS (2001–2010). Fishing years are referred to by the second year (e.g., 1990–91 is referred to as 1991). - insufficient data; –, no analysis. (See Table 11 for ESA area names).

	Longfin (North Island ESAs)									
Year	AA	AB	AC	AD	AE	AG	AH	AJ	AK	AL
1991	1.63	1.32	2.81	1.17	2.64	1.84	2.22	1.7	8.44	1.19
1992	1.44	2.13	2.57	1.48	2.15	1.89	2.49	2.06	1.91	1.9
1993	1.52	1.88	2.36	1.04	1.26	2.1	1.9	1.46	1.02	1.05
1994	1.47	1.78	1.21	1.23	1.44	1.99	2.12	1.29	0.76	1.84
1995	1.46	1.95	1.43	1.34	1.43	1.47	1.71	1.57	0.6	1.34
1996	1.7	1.74	1.33	1.12	0.89	1.45	1.69	1.47	0.8	1.7
1997	1.25	1.14	1.34	1.2	1.27	0.91	1.72	1.27	0.82	1.19
1998	1.65	1.26	1.04	0.86	1.3	1.09	1.09	1.12	2.28	1.16
1999	1.79	1.35	0.82	0.9	2.39	1.48	0.93	0.98	0.7	1.03
2000	1.27	1.46	1.05	1.04	0.84	1.53	1.04	0.89	1.4	1.02
2001	1.28	1.69	0.7	1.06	2.03	1.12	0.81	0.82	0.73	0.67
2002	0.93	1.03	0.91	0.88	0.85	0.76	0.75	0.75	0.67	0.56
2003	0.8	0.9	0.75	0.92	0.96	0.87	0.76	0.74	0.53	0.98
2004	0.98	1.05	0.69	0.93	1.03	0.56	0.65	0.88	0.64	0.64
2005	0.81	0.61	0.9	0.9	0.52	0.8	0.93	0.9	0.94	0.87
2006	0.68	0.59	0.84	0.84	0.68	0.79	1.05	0.95	0.95	0.92
2007	0.84	0.64	0.67	0.8	0.5	0.8	0.74	0.96	0.8	0.77
2008	0.69	0.61	0.77	0.8	0.63	0.66	0.75	0.83	0.77	0.63
2009	0.45	0.49	0.62	0.91	0.72	0.78	0.38	0.55	0.89	0.68
2010	0.48	0.47	0.48	0.89	0.42	0.33	0.6	0.47	1.12	1.21
2011	0.46	0.45	0.63	0.94	0.51	0.4	0.73	0.87	8.44	0.92
2012	0.55	0.47	0.86	1.05	0.77	0.99	0.31	0.88	1.91	1.19

		Longfin (South Island ESAs)							
QMS status	Year	AN	AP_AQ	AR	AT	AU	AV	AW	AX
Pre-QMS	1991	2.29	1.72	1.29	1.89	1.19	1.35	1.46	1.09
	1992	1.15	1.18	0.87	0.74	0.95	1.2	1.13	0.95
	1993	0.8	1.21	1.00	0.78	0.82	1.14	1.13	0.76
	1994	1.06	1.43	1.06	1.05	0.78	1.27	1.22	0.89
	1995	0.85	1.17	0.75	0.88	0.69	0.93	0.99	1.1
	1996	0.81	1.19	1.21	0.78	1.22	0.8	1	0.99
	1997	0.66	0.68	1.09	0.96	1.11	0.86	0.92	0.94
	1998	0.72	0.77	0.75	0.99	0.97	0.87	0.79	0.97
	1999	1.1	0.83	1.02	0.85	1.34	0.85	0.68	1.11
	2000	1.23	0.47	1.10	1.59	1.14	0.91	0.91	1.29

		Longfin (South Island ESAs)							
QMS status	Year	AN	AP_AQ	AR	AT	AU	AV	AW	AX
Post QMS	2001	–	–	–	–	–	–	–	–
	2002	–	–	–	–	–	0.91	1	0.8
	2003	–	–	–	–	–	0.84	1.09	0.79
	2004	–	–	–	–	–	0.92	0.85	0.93
	2005	–	–	–	–	–	1.11	1.1	0.94
	2006	–	–	–	–	–	0.95	1.05	0.96
	2007	–	–	–	–	–	1.05	0.82	1.01
	2008	–	–	–	–	–	0.98	0.92	0.95
	2009	–	–	–	–	–	1.12	0.92	1.06
	2010	–	–	–	–	–	0.94	0.86	1.28
	2011						1.32	1.23	1.23
	2012						0.96	1.15	1.01
	2013						0.99	1.12	1.16

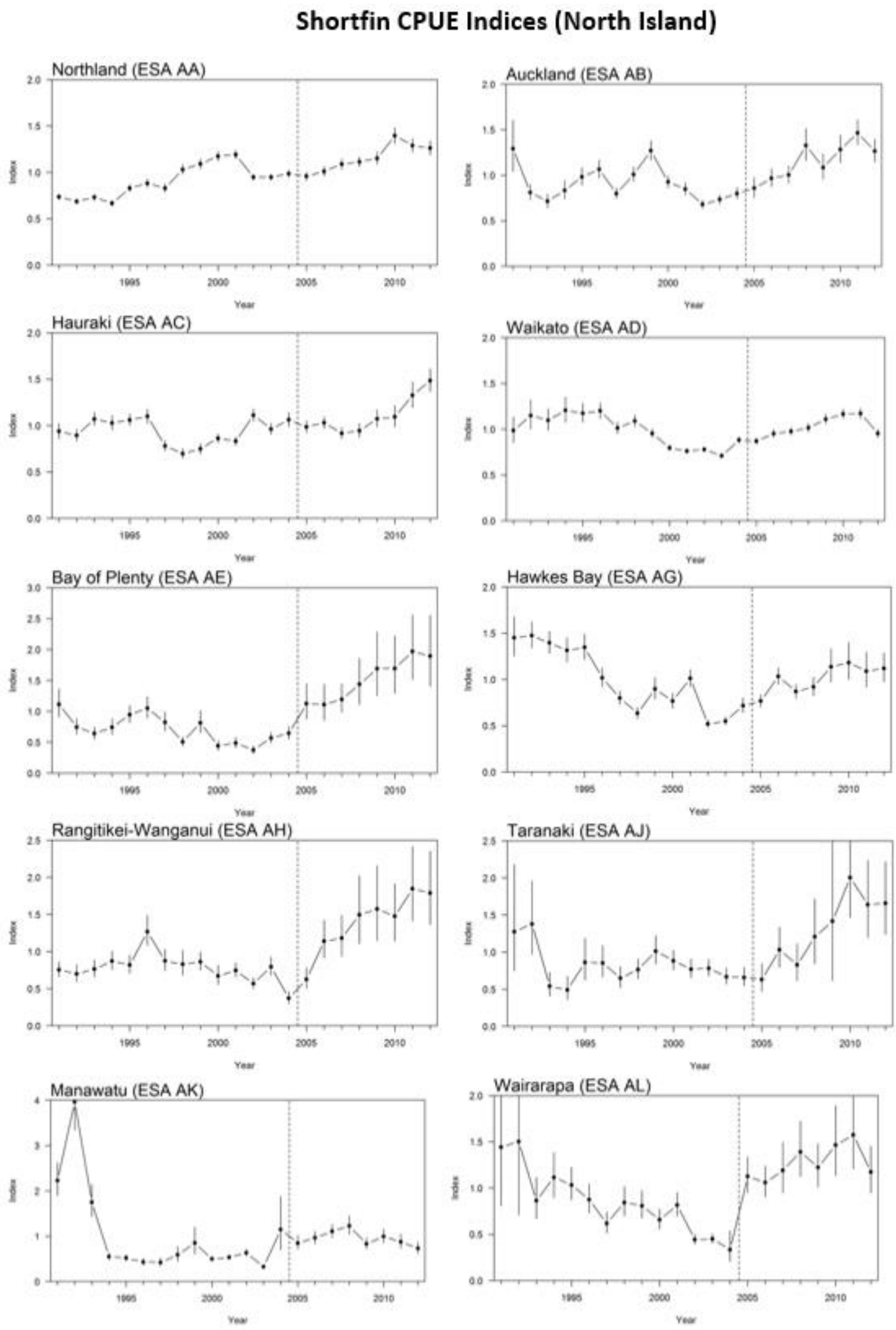


Figure 4: Trends in North Island shortfin CPUE indices for all North Island ESAs from 1990–91 to 2011–12, except Poverty Bay (AE) where there was insufficient data. Vertical dotted line indicates the introduction to the QMS in 2004–05.

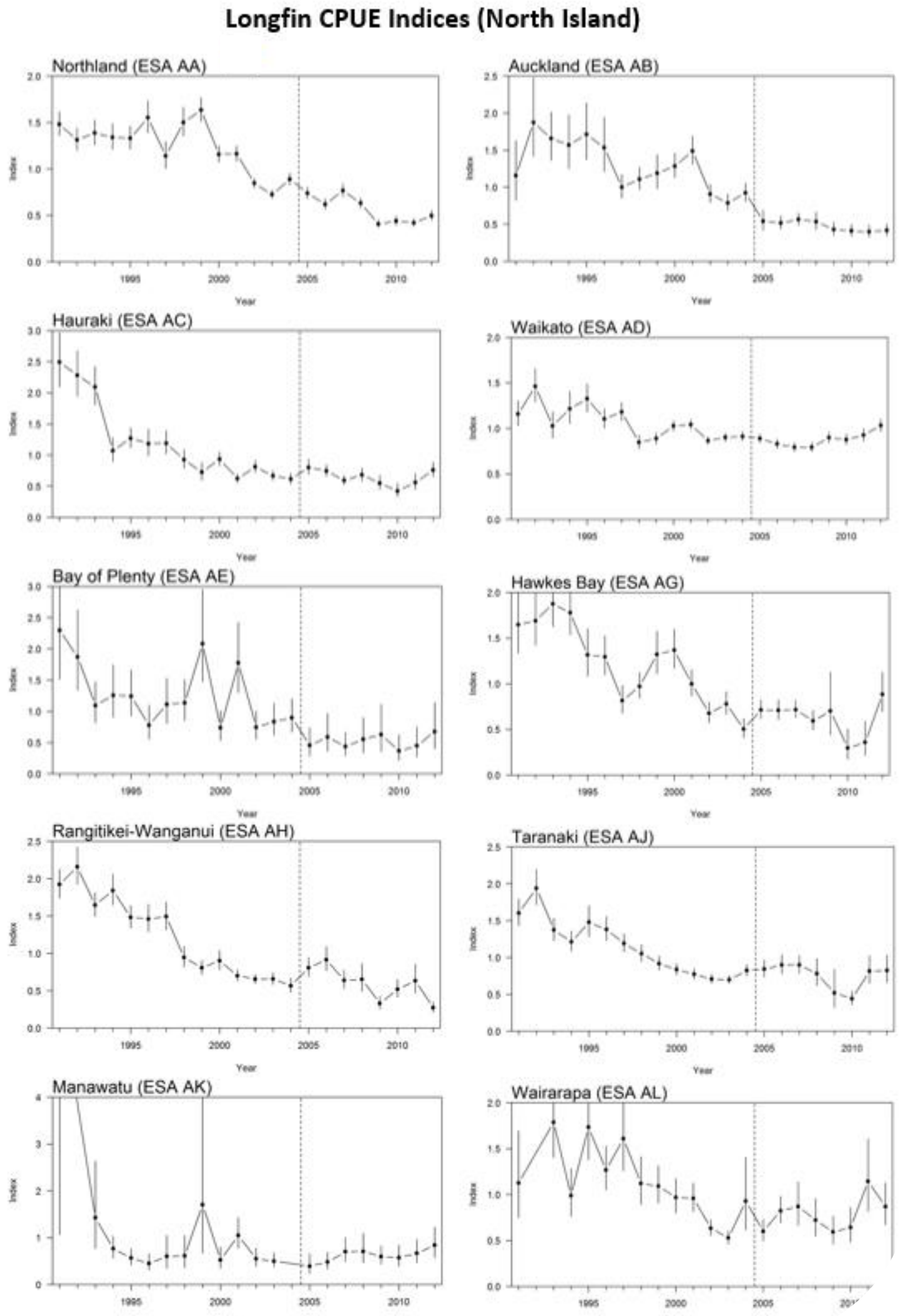


Figure 5: Trends in North Island longfin CPUE indices for all North Island ESAs from 1990–91 to 2011–12, except Poverty Bay (AE) where there was insufficient data. Vertical dotted line indicates the introduction to the QMS in 2004–05. (From Beentjes & Dunn 2013b).

This problem was less severe in the North Island because NI eels were introduced to the QMS after the new ECER forms had been developed, making it possible to link catcher and permit holders before and after the introduction to the QMS. The most recent South Island CPUE analyses, up to 2012–13, included new predictor variables including: target species, water quality data (e.g., nitrogen, phosphates, clarity, temperature), and catcher (Beentjes & Dunn 2015). Catcher was only available for the post-QMS analyses. The first year in the post-QMS standardised CPUE time series is 2001–02 when catcher was first recorded on the new ECERs.

Westland (AX) – Shortfin pre-QMS CPUE fluctuated without trend from 1990–91 to 1996–97 and then increased sharply to 1999–2000. Post-QMS shortfin CPUE increased steadily from 2001–02 to 2012–13. Longfin pre-QMS CPUE declined from 1990–91 to 1992–93, and then increased steadily to 1999–2000. Post-QMS longfin CPUE increased steadily from 2001–02 to 2012–13 (Tables 12 and 13, Figure 6).

Otago (AV) – Shortfin pre-QMS CPUE declined steadily to 1998–99, then increased sharply to 1999–2000. Post-QMS shortfin CPUE increased steadily from 2001–02 to 2010–11, and then declined. Longfin pre-QMS CPUE declined steadily from 1990–91 to 1995–96 and was stable from then to 1999–2000. Post-QMS longfin CPUE was variable but overall increased slightly from 2001–02 to 2012–13 (Tables 12 and 13, Figure 6).

Southland (AW) – Shortfin pre-QMS CPUE declined slowly from 1990–91 to 1996–97 and then gradually increased to 1999–2000. Post-QMS shortfin CPUE was variable but generally increased steadily from 2001–02 to 2012–13. Longfin pre-QMS CPUE declined steadily from 1990–91 to 1999–2000. Post-QMS longfin CPUE was variable and showed a gradual decline from 2001–02 to 2009–10, and then a substantial increase to 2012–13 (Tables 12 and 13, Figure 6).

Te Waihora

CPUE analyses for Te Waihora were only carried out for AS1 feeder shortfin (the lake, outside the migration area) from 2000–01, coinciding with the introduction of the reporting codes (AS1 and AS2), to 2012–13. The most recent analyses included new predictor variables: lake level, status of lake opening (i.e., open or closed), catcher (Beentjes & Dunn 2015). The standardised CPUE time series begins in 2001–02, when the new ECER form was introduced and catcher was first recorded. CPUE of feeder shortfin eels in Te Waihora increased six fold from 2001–02 to 2010–11 and was reasonably stable from 2010–11 to 2012–13 (Figure 7).

It is very likely that the fishery has experienced a progressive improvement in yield per recruit as the minimum legal size was incrementally increased from 140 g in 1993–94 to 220 g in 2001–02. Analyses of eel size composition in the lake in the 1990s compared to that in recent years demonstrates that the size of commercially caught eels has substantially increased over time, supporting the concept of an improved yield per recruit (Figure 8; Beentjes & Dunn 2014).

4.3 Biomass estimates

Estimates of current and reference biomass for any eel fish stock are not available. Recent estimates of approximately 12 000 t have been made for longfin eels (Graynoth et al 2008, Graynoth & Booker 2009), but these are based on limited data on density, growth and sex composition of longfin eel populations in various habitat types, including lakes and medium to large rivers.

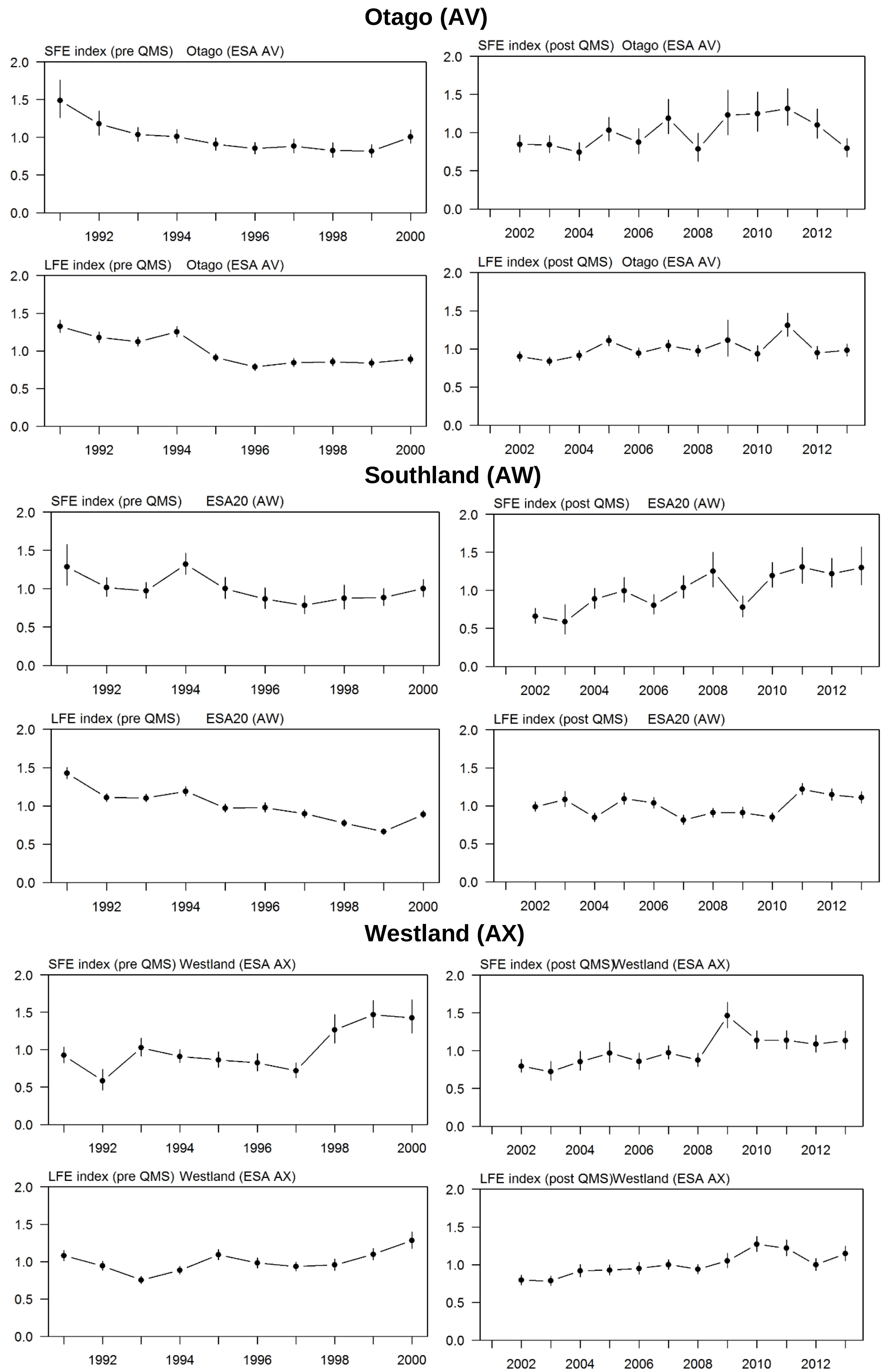


Figure 6: Trends in South Island shortfin and longfin CPUE indices for key ESAs: Otago (AV), Southland (AW), and Westland (AX). Separate indices are presented for pre-QMS (1991–2000) and post-QMS (2002–2013). (From Beentjes & Dunn 2015).

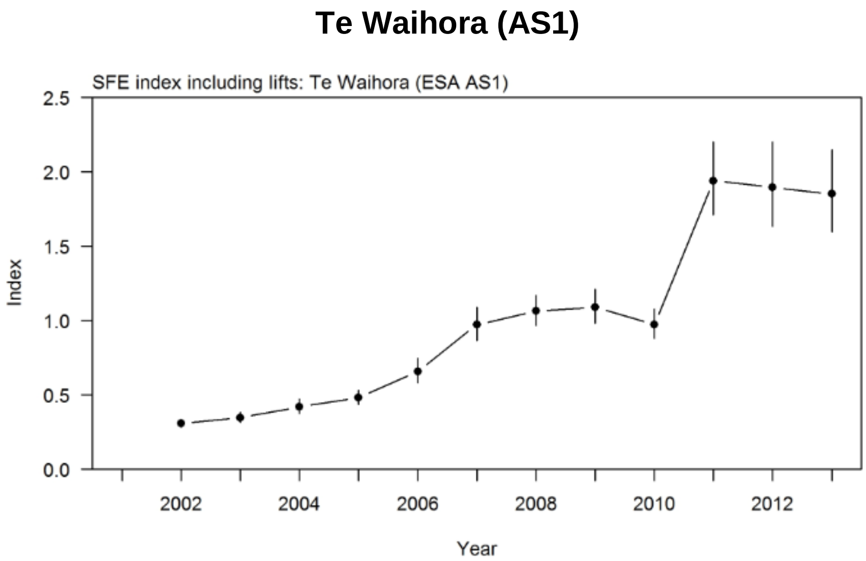


Figure 7: Te Waihora shortfin CPUE indices for AS1 (outside migration area) from 2001–02 to 2012–13. (From Beentjes & Dunn 2015).

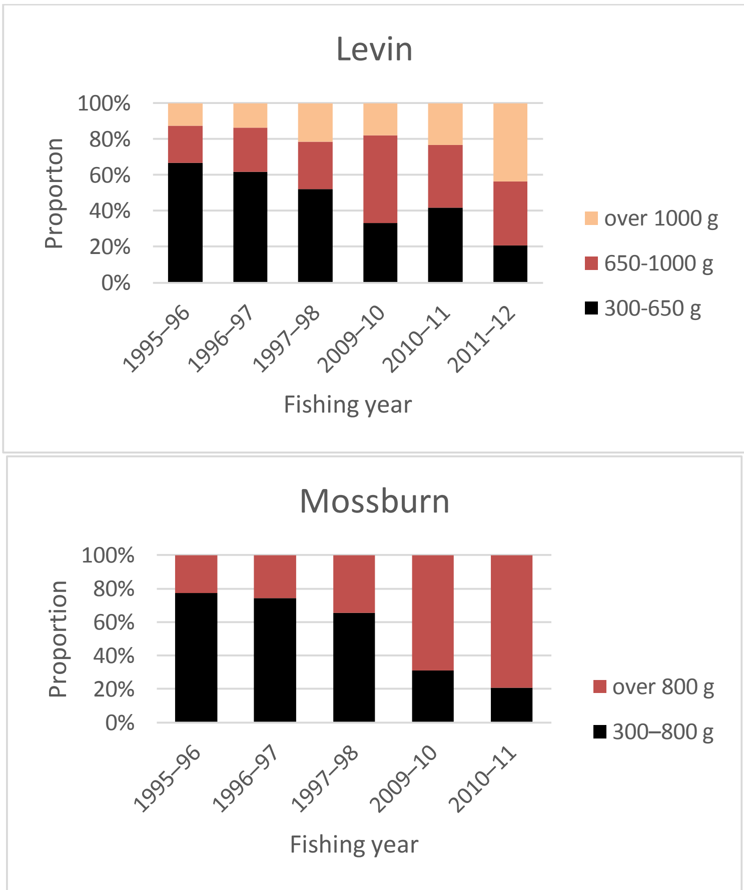


Figure 8: Size grade proportions of shortfin eels harvested from Te Waihora AS1 (lake) from eel processors Levin Eel Trading Ltd in 2009–10 to 2011–12, and Mossburn Enterprises Ltd in 2010–11 and 2011–12. The equivalent size grades have been estimated from the length of eels taken during commercial catch sampling of the commercial catch in 1995–96 to 1997–98 (from Beentjes & Dunn 2014).

4.4 Yield estimates and projections

In the absence of accurate current biomass estimates, this could not be estimated. Biological parameters relevant to the stock assessment are given in Table 14.

Table 14: Estimates of biological parameters

Fishstock	Estimate	Source
1. Natural mortality (*M*)		
Unexploited shortfins (Lake Pounui)	*M* = 0.038	Jellyman (unpub. Data)
Unexploited longfins (Lake Pounui)	*M* = 0.036	Jellyman (unpub. Data)
Unexploited longfins (Lake Rotoiti)	*M* = 0.02	Jellyman (1995)
2. Weight (g) of shortfin and longfin eels at 500 mm total length		
	Mean weight	Range
Shortfins Lake Pounui	263	210–305
Shortfins Waihora	250	210–303
Longfins Lake Pounui	307	250–380

4.5 Other factors

Yield-per-recruit

Yield-per-recruit (YPR) models have been run on Te Waihora (Lake Ellesmere) and Lake Pounui data to test the impact of increases in size limit. Results indicated that an increase in minimum size should result in a small gain in YPR for shortfins in Te Waihora and longfins in Lake Pounui, but a decrease for shortfins in Lake Pounui.

A practical demonstration of the benefits of an increase in size limit has been reported from the Waikato area, where a voluntary increase in minimum size from 150 to 220 g in 1987 resulted in decreased CPUE for up to 18 months, but an increase thereafter.

Spawning escapement

A key component to ensuring the sustainability of eels is to maintain spawner escapement. As a sustainability measure, the Mohaka, Motu and much of the Whanganui River catchments were closed to commercial fishing in early 2005 to aid spawning escapement. The importance of adequate spawner escapement for eels is evident from the three northern hemisphere (*A. anguilla, A. rostrata* and *A. japonica*) species, which are all extensively fished at all stages of their estuarine/freshwater life stage and are subject to a variety of anthropogenic impacts similar to the situation in New Zealand. There has been a substantial decline in recruitment for all three northern hemisphere species since the mid-1970s with less than 1% of juvenile resources estimated to be remaining for major populations in 2003 (Quebec Declaration of Concern 2003).“The recent recruitment increase of some stocks, and the relative stability of others, indicate that after many decades of continued decline depleted eel stocks around the world have the potential to recover” (Dekker & Casselman 2014).

Based on GIS modelling it has been estimated that for longfin eels, 5% of habitat throughout New Zealand is in water closed to fishing where there is protected egress to the sea to ensure spawning escapement. A further 10% of longfin habitat is in areas closed to fishing in upstream areas but where the spawning migration could be subject to exploitation in downstream areas (migratory eels are not normally taken by commercial fishers). An additional 17% of longfin habitat is in small streams that are rarely or not commercially fished. Therefore, about 30% of longfin habitat in the North Island and 34% in the South Island is either in a reserve or in rarely/non-fished areas (Graynoth et al 2008).

Sex ratio

The shortfin fishery is based on the exploitation of immature female eels, as most shortfin male eels migrate before reaching the minimum size of 220 g. The exception being Te Waihora where migratory male shortfin eels are also harvested. The longfin fishery is based on immature male and female eels.

A study on the Aparima River in Southland in 2001–02 found that female longfins were rare in the catchment. Only five of 738 eels sexed were females (McCleave & Jellyman 2004). This is in contrast to a predominance of larger female longfins in southern rivers established by earlier research in the 1940s and 1950s, prior to commercial fishing. The sex ratio in other southern catchments, determined from analysis of commercial landings, also show a predominance of males. In contrast some other catchments (Waitaki River, some northern South Island rivers) showed approximately equal sex ratios. The predominance of males in the size range below the minimum legal size of 220 g cannot be attributed directly to the effects of fishing. Because the sexual differentiation of eels can be influenced by environmental factors, it is possible that changing environmental factors are responsible for the greater proportion of male eels in these southern rivers (Davey & Jellyman 2005).

Enhancement

The transfer of elvers and juvenile eels has been established as a viable method of enhancing eel populations and increasing productivity in areas where recruitment has been limited. Elver transfer operations are conducted in summer months when elvers reach river obstacles (e.g., the Karapiro Dam on the Waikato River; see Table 10a) on their upriver migration. Nationally some 10 million elvers are now regularly caught and transferred upstream of dams each year.

To mitigate the impact of hydro turbines on migrating eels, a catch and release programme for large longfin females has been conducted from Lake Aniwhenua with release below the Matahina Dam since 1995. An extensive capture and release programme has also been conducted from Lake Manapöuri to below the Mararoa Weir on the Waiau River, Southland by Meridian Energy since 1998. Limited numbers of longfin migrants are also transferred to below the Waitaki Dam by local Runanga. Adult eel bypasses have been installed at the Wairere Falls and Mokauiti power stations in the Mokau River catchment since 2002 and controlled spillway openings have been undertaken at Patea Dam during rain events in autumn (when eels are predicted to migrate downstream) since the late 1990s. Additional eel protection infrastructure are currently being installed at Patea Dam and ongoing studies, including downstream bypass trials are in progress at Karapiro Dam (Waikato), Lake Whakamarino (Waikaremoana Power Scheme) and Wairua (Titoki) Power Station. So far, the effectiveness of none of these varied mitigation activities has been fully assessed.

Several projects have been undertaken to evaluate the enhancement of depleted customary fisheries through the transfer of juvenile eels. In 1997, over 2000 juvenile shortfin eels (100–200 g) were caught from Te Waihora (Lake Ellesmere), tagged and transferred to Cooper’s Lagoon a few kilometres away (Jellyman & Beentjes 1998, Beentjes & Jellyman 2002). Only ten tagged eels, all females, were recovered in 2001. It is likely that a large number of eels migrated to sea as males following the transfer. Another project in 1998 transferred 7600 (21% tagged) mostly shortfin eels weighing less than 220 g from Lake Waahi in the Waikato catchment to the Taharoa Lakes near Kawhia (Chisnall 2000). No tagged eels were recovered when the lakes were surveyed in 2001. It is considered that a large number of shortfin eels migrated from the lake as males following the transfer. The conclusion from these two transfers is that transplanted shortfin eels need to be females, requiring that eels larger than 220 g and above the maximum size of migration for shortfin males need to be selected for transfer.

In 1998 approximately 10 000 juvenile longfin eels were caught in the lower Clutha River and transferred to Lake Hawea, of which 2010 (about 20%) were tagged (Beentjes 1998). In 2001, of 216 recaptured eels, 42 (19.4%) had tags (i.e. very little tag loss) (Beentjes & Jellyman 2003) . The transferred eels showed accelerated growth and the mean annual growth in length was almost double that of eels from the original transfer site and all recaptures were females. A further sample of Lake Hawea in 2008 showed that of 399 longfin eel recaptures, 79 had tags (19.2%), indicating continued good tag retention (Beentjes & Jellyman 2011). Growth rate from the 2008 tag-recaptures was significantly greater than at release, but less than in 2001 and all recaptures were females.

Trends in the commercial catches from areas upstream of hydro dams on the Waikato, Rangitaiki and Patea rivers indicate that elver trap and transfer operations has improved or at least maintained the eel populations upstream of barriers (Beentjes & Dunn, 2010). Comparison of historical eel survey results have confirmed these observations (e.g. Beentjes et al 1997, Boubée et al 2000, Boubée & Hudson 2009, Crow & Jellyman 2010)

5. FUTURE RESEARCH NEEDS

- The potential influence of zero catches should be considered in future CPUE analyses for the post-2002 period (when use of the EEU code ceased), and a combined index should be produced. In a number of instances, the proportion of zeros is high, and there is often a negative correlation between the proportion of zeros for longfin and shortfin.
- The "target species" reconstruction based on CELR data needs to be examined further by, for example, running sensitivities to determine the effect of different assumptions.
- The "core selection" should only be conducted for the catcher and not the permit holder, given that there can be more than one catcher per permit, some of which may not fish for many years.
- For the Te Waihora shortfin CPUE, explore the possibility of developing an index of the ratio between the AS1 and AS2 catch as a potential explanatory variable.

6. STATUS OF THE STOCKS

There are no Level 1 Full Quantitative Stock Assessments on which to base specific recommendations on eel catch levels. Nevertheless, recruitment data, commercial CPUE indices, and information on spawner escapement allow for cautioned assessments of longfin and shortfin eels using Level 2 Partial Quantitative Stock Assessments.

Stock Structure Assumptions

Longfin and shortfin eels comprise New Zealand wide stocks, with common species-specific spawning grounds within the Fiji Basin. However, once recruited to a river system, eels do not move between catchments, so eels within each catchment may be regarded as separate sub-populations for management purposes. Maintaining sub-populations within each QMA at or above B_{MSY}, will ensure that the entire (national) stock of each species is maintained at that level.

Status of North Island Eels

Given the potential negative impact of North Island regulation changes on CPUE as an index of abundance, only South Island longfin and shortfin eels have been assessed using Level 2 Partial Quantitative Stock Assessments. North Island eel populations will be assessed using Level 2 assessments when the standardized CPUE indices are next updated (in 2016). Approximately 30% of available longfin habitat in the North Island is either in reserves or in rarely/non-fished areas.

Status of South Island Eels

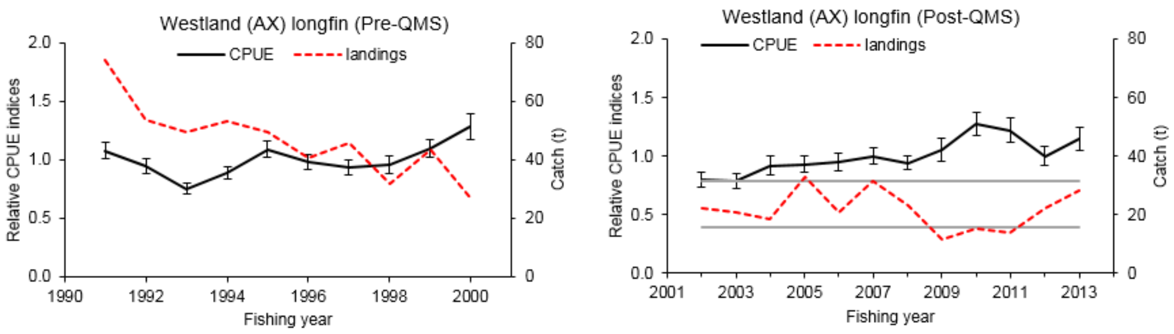
Level 2 Partial Quantitative Stock Assessments are conducted by statistical area and species, and are only possible where accepted indices of abundance are available; i.e. Westland, Otago, Southland and Te Waihora). Standardised CPUE provides information on the abundance of commercially harvested eels (300 g–4000 g) in areas that are fished commercially. Aproximately 34% of currently available longfin habitat on the South Island is either in reserves or in rarely/non-fished areas.

- **Westland (AX) longfin**

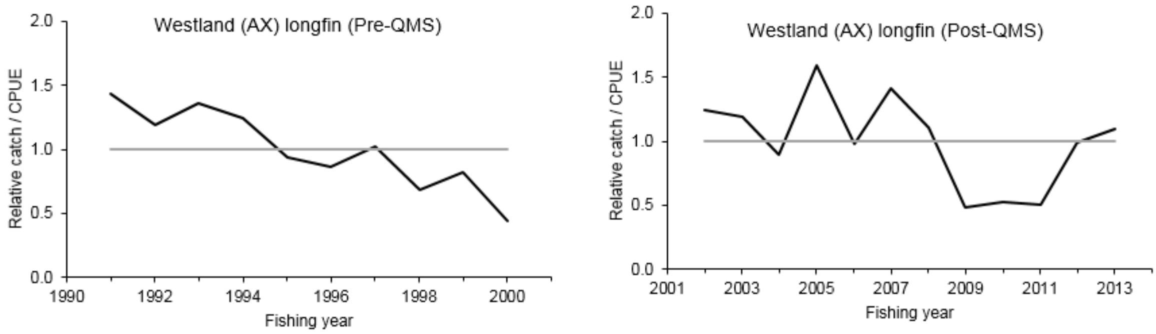
Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2001–02 to 2002–03 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated

Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for longfin eels in Westland (AX) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated longfin catch in AX from ECERs. The two CPUE series have been scaled to the mean for each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for longfin eels in the Westland (AX) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Pre-QMS CPUE declined from 1990–91 to 1992–93, and then increased steadily to 1999–2000. Post-QMS CPUE increased steadily from 2001–02 to 2012–13.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate declined steeply throughout the pre-QMS time series and generally declined from 2001–02 to 2008–09 before increasing to 2012–13 post-QMS.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of longfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.
Projections and Prognosis	
Stock Projections or Prognosis	Unlikely (< 40%) to decline in the medium term under current catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) if catch remains at current levels Hard Limit: Unlikely (< 40%) if catch remains at current levels South Island TACCs include both longfin and shortfin eels. As the TACC is substantially higher than the current longfin eel catch, it is not meaningful to evaluate potential impacts if catches of longfins increased to the level of the TACC.

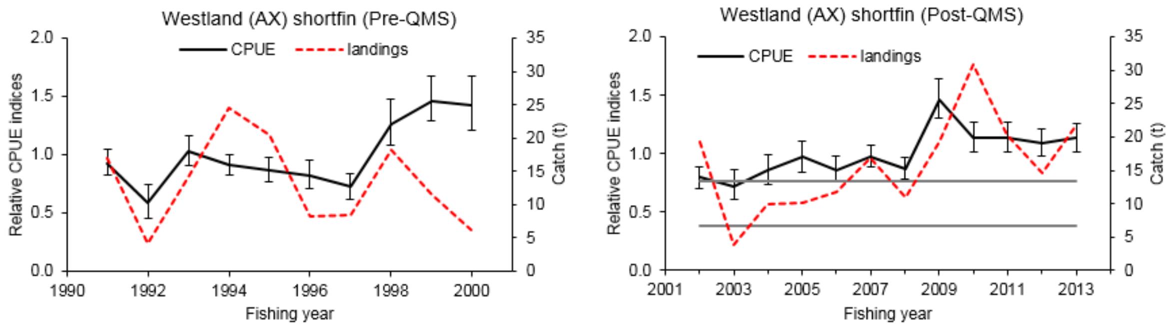
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Likely (> 60%) if catch were to increase to the level of the TACC	
Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available.
Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include brown trout, galaxiids, yellow-eyed mullet, and koura in order of amount caught. Bycatch species are usually returned alive.

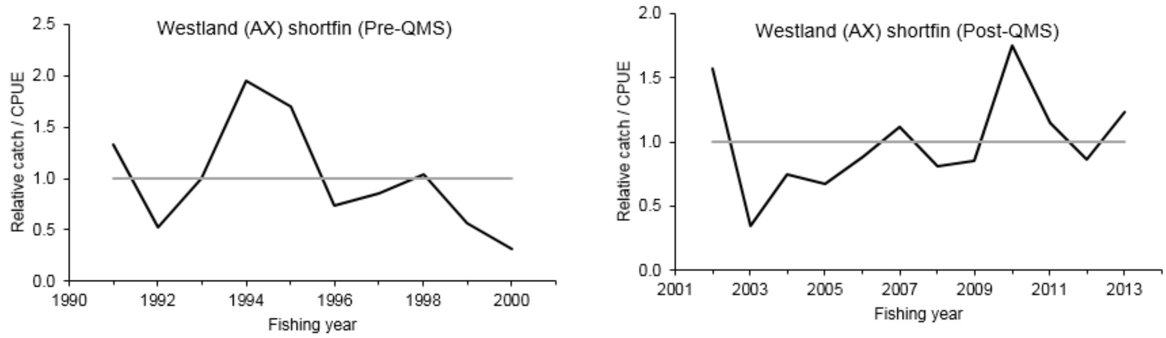
- **Westland (AX) shortfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2001–02 to 2002–03 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for shortfin eels in Westland (AX) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated shortfin catch in AX from ECERs. The two CPUE series have been scaled to the mean of each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for shortfin eels in the Westland (AX) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Pre-QMS CPUE fluctuated without trend from 1990–91 to 1996–97 and then increased sharply to 1999–2000. Post-QMS CPUE increased steadily from 2001–02 to 2012–13.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate has shown large inter-annual fluctuations, with an increasing trend since 2003.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of shortfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.
Projections and Prognosis	
Stock Projections or Prognosis	Unlikely (< 40%) to decline in the medium term under current catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) if catch remains at current levels Hard Limit: Very Unlikely (< 10%) if catch remains at current levels South Island TACCs include both longfin and shortfin eels. As the TACC is approximately 2–3 times higher than the current shortfin eel catch, it is not meaningful to evaluate potential impacts if catches of shortfins were to increase to the level of the TACC.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Likely (> 60%) if catch were to increase to the level of the TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

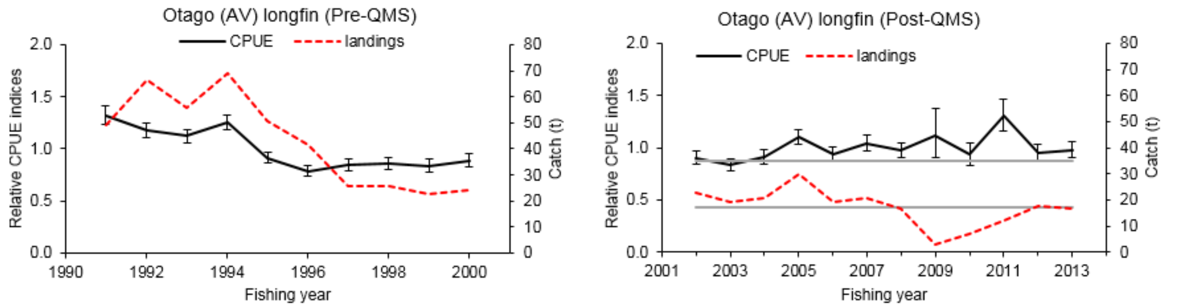
Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available.

Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include brown trout, galaxiids, yellow-eyed mullet, and koura in order of amount caught. Bycatch species are usually returned alive.

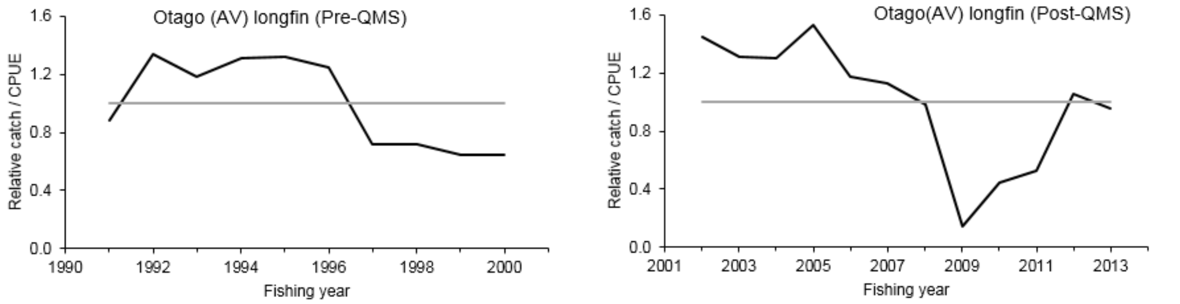
- **Otago (AV) longfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2001–02 to 2002–03 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for longfin eels in Otago (AV) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated longfin catch in AV from ECERs. The two CPUE series have been scaled to the mean of each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for longfin eels in the Otago (AV) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends		
Recent Trend in Biomass or Proxy	Pre-QMS CPUE declined steadily from 1990–91 to 1995–96 and was stable to 1999–2000. Post-QMS CPUE is variable, but overall increased marginally from 2001–02 to 2012–13.	
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate declined markedly from 2002 to 2009 and then increased to the average for the post-QMS series.	
Other Abundance Indices	-	
Trends in Other Relevant Indicators or Variables	Catches of longfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.	
Projections and Prognosis		
Stock Projections or Prognosis	Unlikely (< 40%) to decline in the medium term if catch remains at current levels	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: About as Likely as Not (40–60%) if catch remains at current levels Hard Limit: Unlikely (< 40%) if catch remains at current levels South Island TACCs include both longfin and shortfin eels. ANG 15 comprises statistical areas AV (Otago) and AW (Southland). As the TACC is substantially higher than the current longfin eel catch, it is not meaningful to evaluate potential impacts if catches were to increase to the level of the TACC.	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Unknown if catch were to increase to the level of the TACC	
Assessment Methodology		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017

Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

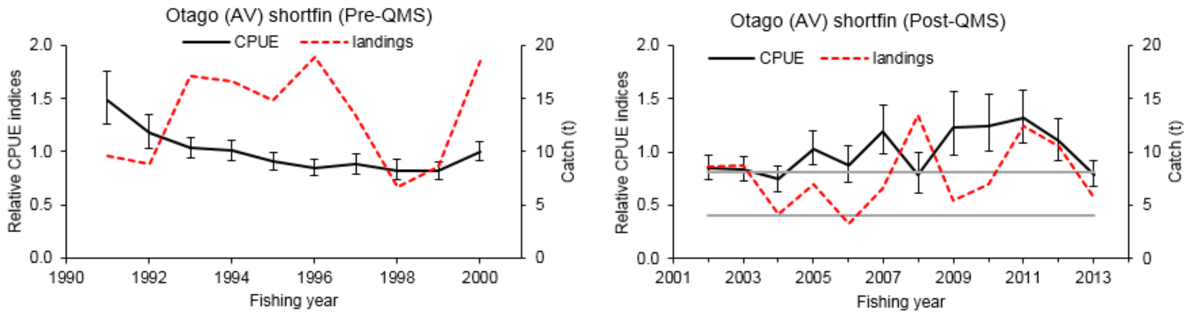
Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available.

Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include brown trout, galaxiids, yellow-eyed mullet, and koura in order of amount caught. Bycatch species are usually returned alive.

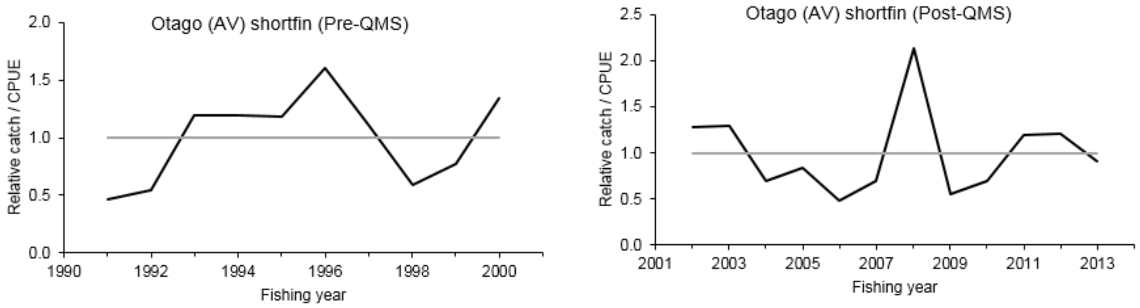
- **Otago (AV) shortfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2001–02 to 2003–04 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: About as Likely as Not (40–60%) to be below Hard Limit: Unlikely (< 40%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for shortfin eels in Otago (AV) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated shortfin catch in AV from ECERs. The two CPUE series have been scaled to the mean of each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for shortfin eels in the Otago (AV) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Pre-QMS CPUE declined steadily from 1990–91 to 1998–99 and then increased slightly to 1999–2000. Post-QMS CPUE increased steadily from 2001–02 to 2010–11, and then declined markedly to just below the long-term average.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate has fluctuated without trend since 2002.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of shortfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.

Projections and Prognosis	
Stock Projections or Prognosis	As both catch and exploitation rate show large inter-annual variation, it is not clear whether the population will continue to decline.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: About as Likely as Not (40–60%) if catch remains at current levels Hard Limit: Unlikely (< 40%) if catch remains at current levels South Island TACCs include both longfin and shortfin eels. ANG 15 comprises statistical areas AV (Otago) and AW (Southland). The TACC is 6–7 fold higher than the current shortfin eel catch in ANG 15. Catch at the level of the TACC is Likely (> 60%) to cause decline below both the soft and hard Limits
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Likely (> 40%) if catch were to increase to the level of the TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

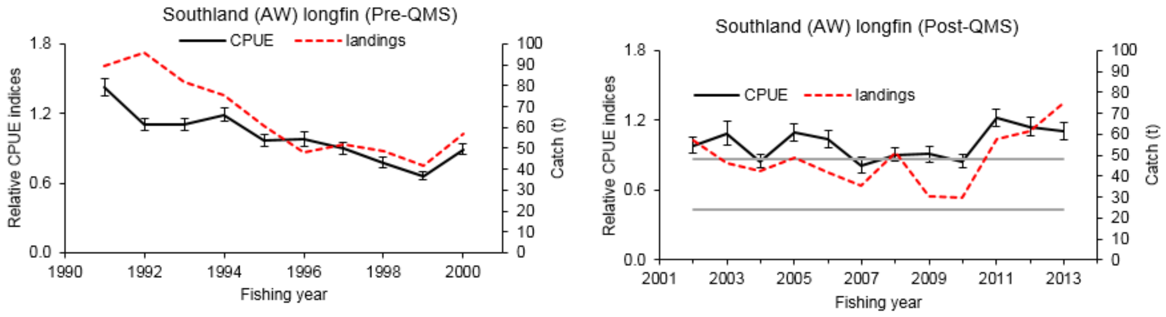
Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series.

Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include: brown trout, black flounder, koura, yellow-eyed mullet, galaxiids, yellowbelly flounder, and bullies in order of amount caught. Bycatch species are usually returned alive.

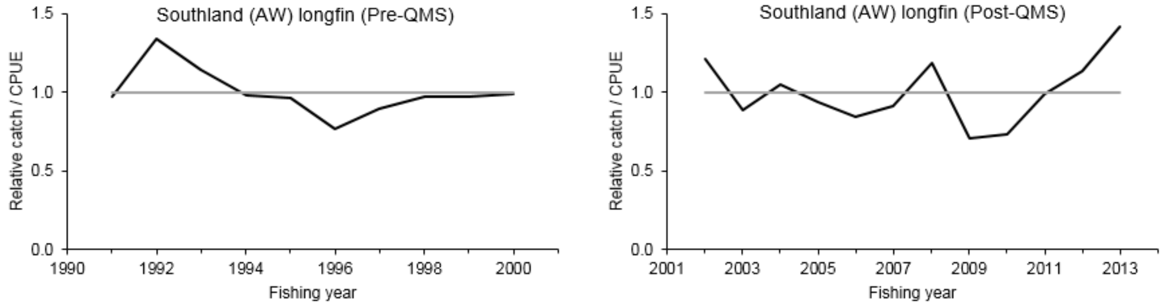
- **Southland (AW) longfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2006–07 to 2009–10 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for longfin eels in Southland (AW) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated longfin catch in AW from ECERs. The two CPUE series have been scaled to the mean of each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for longfin eels in the Southland (AW) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Pre-QMS CPUE declined steadily from 1990–91 to 1998–98 and increased to 1999–2000. Post-QMS CPUE is variable and showed a gradual decline from 2001–02 to 2009–10, then an increase since.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate declined from 2002 to 2010 and then increased steeply to well above the long-term average to 2013.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of longfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.
Projections and Prognosis	
Stock Projections or Prognosis	Likely (> 60%) to decline under recent levels of catch and exploitation rate
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) if catch remains at current levels Hard Limit: Unlikely (< 40%) if catch remains at current levels South Island TACCs include both longfin and shortfin eels. ANG 15 comprises statistical areas AV (Otago) and AW (Southland). As the TACC is substantially higher than the current longfin eel catch, it is not meaningful to evaluate potential impacts if catches increased to the level of the TACC.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Very Likely (> 90%) if catch were to increase to the level of the TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

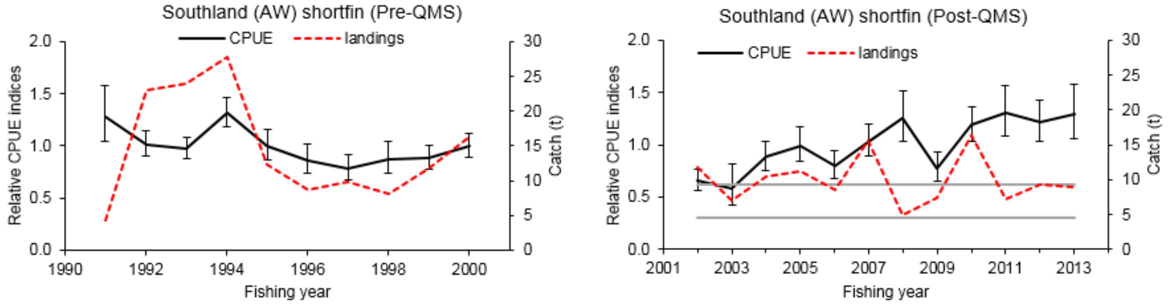
Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available.

Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include brown trout, giant bullies, koura, galaxiids, and common bullies in order of amount caught. Bycatch species are usually returned alive.

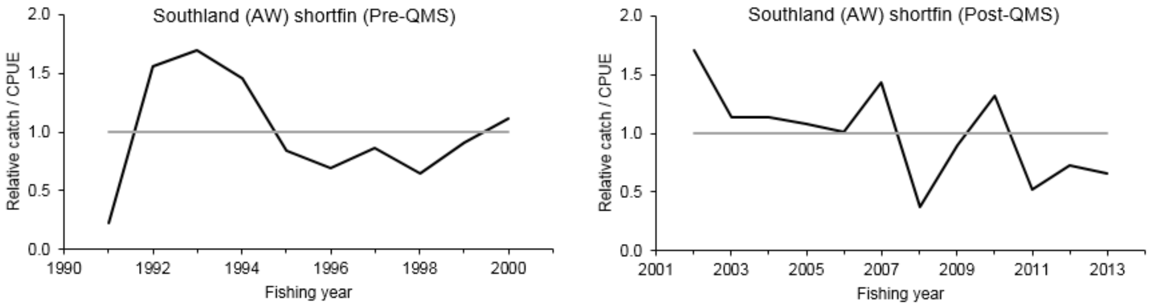
- **Southland (AW) shortfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE
Reference Points	Target: B_{MSY} assumed, but not estimated Interim Soft Limit: Mean CPUE from 2001–02 to 2002–03 Hard Limit: 50% of Soft Limit Overfishing threshold: F_{MSY} assumed, but not estimated
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for shortfin eels in Southland (AW) from 1990–91 to 1999–2000 (pre-QMS) and 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated shortfin catch in AW from ECERs. The two CPUE series have been scaled to the mean of each time series. Horizontal lines represent the soft and hard limits. 2000 = 1999–2000 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for shortfin eels in the Southland (AW) pre- and post-QMS. 2000 = 1999–2000 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Pre-QMS CPUE declined slowly from 1990–91 to 1996–97 and then gradually increased to 1999–2000. Post-QMS CPUE fluctuated but increased substantially from 2001–02 to 2012–13.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate shows high inter-annual variation, but a consistently declining trend since 2002.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of shortfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment.
Projections and Prognosis	
Stock Projections or Prognosis	Likely (> 60%) to continue to increase in the medium term under current catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) if the catch remains at current levels Hard Limit: Very Unlikely (< 10%) if the catch remains at current levels South Island TACCs include both longfin and shortfin eels. ANG 15 comprises statistical areas AV (Otago) and AW (Southland). As the TACC is substantially higher than the current longfin eel catch, it is not meaningful to evaluate potential impacts if catches increased to the level of the TACC.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown if catch remains at current levels Likely (> 60%) if catch were to increase to the level of the TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Uncertainty in target species after 2000 • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

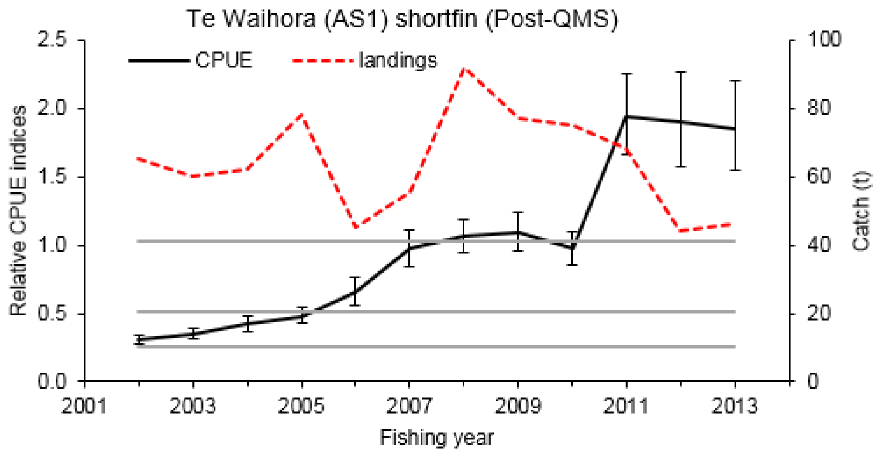
Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available.

Fishery Interactions
Bycatch of other species in the commercial eel fishery is low, and may include brown trout, giant bullies, koura, galaxiids, and common bullies in order of amount caught. Bycatch species are usually returned alive.

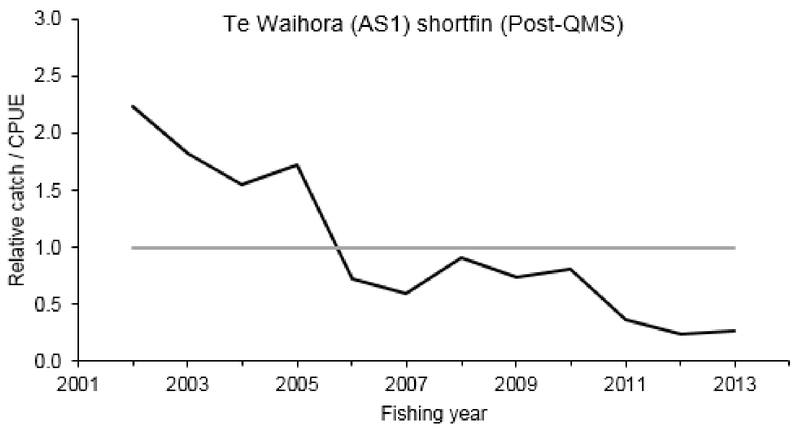
- **Te Waihora (AS1) shortfin**

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Standardised CPUE of feeder eels in AS1
Reference Points	Interim Target: B_{MSY}-compatible proxy based on mean CPUE for the period: 2006–07 to 2009–10. Soft Limit: 50% of target Hard Limit: 50% of soft limit Overfishing threshold: F_{MSY}
Status in relation to Target	Very Likely (> 60%) to be at or above B_{MSY}
Status in relation to Limits	Soft Limit: Very Unlikely (< 10%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



Comparison of standardised CPUE for shortfin eels in Te Waihora (AS1) from 2001–02 to 2012–13 (post-QMS) (from Beentjes & Dunn 2015). Also shown is the total estimated shortfin catch in AS1 from ECERs. The CPUE series have been scaled to the mean of each time series. Horizontal lines represent the target, and soft and hard limits. 2002 = 2001–2002 fishing year. Error bars are 95% confidence intervals.



Annual relative exploitation rate for shortfin eels in the Te Waihora (AS1) post-QMS. 2002 = 2001–02 fishing year.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE of feeder shortfin eels in Te Waihora (AS1) increased 6-fold from 2001–02 to 2010–11, but showed no trend to 2012–13.
Recent Trend in Fishing intensity or Proxy	Relative exploitation rate has declined substantially (9-fold) since 2002, and is now well below the series average.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Catches of shortfin elvers at primary monitoring sites have fluctuated without trend since the series of reliable data begins in 1995–96, suggesting no overall trend in recruitment. Increasing mean size since the mid-1990s suggests reduced exploitation rates.

Projections and Prognosis	
Stock Projections or Prognosis	Likely (> 60%) to remain well above the target in the medium term under current catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) if catch remains at current levels Hard Limit: Very Unlikely (< 10%) if catch remains at current levels Unlikely (< 40%) if catch were to increase to the level of the TACC, provided not all of the catch is taken from AS1
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unlikely (< 40%) if catch remains at current levels Unlikely (< 40%) if catch were to increase to the level of the TACC, provided not all of the catch is taken from AS1

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Standardised CPUE based on positive catches from commercial fyke net	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Standardised CPUE only provides an index of abundance for eels in areas fished by commercial fishers. Other potential issues with the CPUE indices include: • Low numbers of fishers • Exclusion of zero catches • Changes in MLS and retention in early parts of the series (pre-QMS)	

Qualifying Comments
Because the commercial eel fishery has had a long history (beginning in the late 1960s), and indices of abundance are only available from the early 1990s, it is difficult to infer stock status from recent abundance trends, and these should therefore be interpreted with caution. Other sources of mortality, such as culling (primarily 1930s to 1950s) and habitat alteration (historical and current) have also reduced abundance prior to the CPUE series. The shortfin eel catch from Te Waihora comprises small migrant males from AS2 and feeder females from AS1. The index of abundance is based on the catch rates of feeder eels. The basis for the biological reference points is tenuous, and should be revised whenever new relevant information becomes available. Shortfin eels in Te Waihora have a markedly different (mostly strongly increasing) pattern in CPUE compared to other eel sub-populations. This could be due to a number of factors, both positive and negative, including eutrophication, and changes in productivity, lake opening regimes, and management measures.

Fishery Interactions
Bycatch of other species in the commercial eel fishery may include: bullies, black flounder, yellowbelly flounder, sand flounder, and goldfish in order of the amount caught. The flatfish species are usually released alive or retained if caught under quota. Longfin eels are not abundant and are usually voluntarily released alive. All other bycatch is released alive.

6. FOR FURTHER INFORMATION

Beentjes, M P (1998) Enhancement of Lake Hawea eel stocks by transfer of juveniles. *NIWA Technical Report 41*. 15 p.

Beentjes, M P (1999) Size, age, and species composition of South Island commercial eel catches from market sampling (1997–98). *NIWA Technical Report 51*. 51 p.

Beentjes, M P (2005) Monitoring commercial eel fisheries in 2003–04. *New Zealand Fisheries Assessment Report 2005/39*. 57 p.

Beentjes, M P (2008) Monitoring commercial eel fisheries in 2003–04 and 2004–05. *New Zealand Fisheries Assessment Report 2008/19*. 43 p.

Beentjes, M P (2011) Monitoring commercial eel fisheries in 2007–08 and 2008–09. *New Zealand Fisheries Assessment Report 2011/50*.

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Beentjes, M P; Boubée, J A T; Jellyman, D J; Graynoth, E (2005) Non-fishing mortality of freshwater eels (*Anguilla* spp.). *New Zealand Fisheries Assessment Report 2005/34*. 38 p.

Beentjes, M P; Bull, B (2002) CPUE analyses of the commercial freshwater eel fishery. *New Zealand Fisheries Assessment Report 2002/18*. 55 p.

Beentjes, M P; Chisnall, B L (1997) Trends in size and species composition and distribution of commercial eel catches. *New Zealand Fisheries Data Report 89*, 71 p.

Beentjes, M P; Chisnall, B L (1998) Size, age, and species composition of commercial eel catches from market sampling, 1996–97. *NIWA Technical Report 29*. 124 p.

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